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FLO-FLO Sea Basing Concept Ship Model Testing

by

Ciara Chaffee, Timothy Lester, and Justin Sobol

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Ciara Chaffee
Timothy Lester
Justin Sobol

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Naval Surface Warfare Center
Carderock Division
9500 Macarthur Boulevard
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14. ABSTRACT
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Abstract

The FLO/FLO is a concept ship that could support the MPF(F) squadron with responsibilities such as skin to skin interfaces, LCAC and EFV deployment and recovery, and LCU interface. The goal of this study was to test the FLO/FLO concept ship 1:60 scale model in the NSWCCD 140 foot basin at two specific loading conditions, LCAC operations and EFV recovery, and irregular head seas to determine the amount of deck wash, the wake, and seakeeping characteristics with two transom configurations. Testing included observations made with and without a stern extension at four velocities in Sea States 2 and 4. In the EFV ballasting condition, the model had increased weight, drafts, and trim angles to create a beach like transom to efficiently recover the vehicles. Less ballast is required for LCAC operations and the model was at its lightest. The stern extension was the largest factor in the model performance. The model fitted with a stern extension had decreased water entry lengths and better seakeeping results. Results of the testing will help to determine future stern configurations and modifications necessary to increase the overall capabilities of this concept ship.

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Nomenclature

ϕ	Heel angle
α	Trim angle
B	Beam
BL_{ref}	Reference baseline
BM	Distance from center of buoyancy to the transverse metacenter
B_{WL}	Beam at waterline
CISD	Center for Innovation in Ship Design
COG	Center of Gravity
CSC	Computer Science Corporation
EFV	Expeditionary Fighting Vehicle
*f**	Frame
FLO/FLO	Float on/Float off vessel
F_n	Froude Number
G	Center of Gravity
g	Gravity
GM	Metacentric height
GZ	Righting arm
I_L	Pitching moment of inertia of the system
I_P	Pitching moment of inertia of the model
I_R	Rolling moment of inertia of the model
I_T	Rolling moment of inertia of the system
I_{xx}	Moment of inertia of the water plane through the center of flotation
KG	Distance from keel to center of gravity
KM	Distance from keel to transverse metacenter
LCAC	Landing Craft Air Cushion
LCG	Longitudinal center of gravity
LMSR	Large, Medium Speed, Roll-on/Roll-off
LOA	Length overall
L_{PP}	Length between perpendiculars
L_{WL}	Length Waterline
M	Transverse metacenter
*M**	Model
MPF(F)	Maritime Prepositioning Force (Future)
NATO	North Atlantic Treaty Organization
NSWCCD	Naval Surface Warfare Center Carderock Division
S	Wetted surface area
*S**	Ship
SS	Sea State
STANAG 4194	*NATO* Standardized wave and wind environments and shipboard reporting of sea conditions
*sys**	System
T_{AFT}	Draft at aft perpendicular
T_{FWD}	Draft at forward perpendicular

V	Velocity
VCG	Vertical center of gravity
w	Small weight used to produce small angles
W	Weight of large objects
x_w	Longitudinal distance of small weight
Z	Vertical height from the baseline up
z_w	Vertical height of the small weight

1. Introduction

1.1. Objectives

The objectives of this study were to:

1. Determine the characteristics of deck wash due to the interaction of the concept *FLO/FLO* ship and irregular head seas at different ballasting conditions and gate configurations
2. Observe and empirically measure the *FLO/FLO* model's seakeeping qualities in irregular head seas at various speeds, sea states, stern configurations, and ballasting conditions
3. Use flow visualization to observe the wake of the transom at different operating configurations in irregular head seas

To achieve these objectives, a model of the *FLO/FLO* ship was constructed and tested in the *NSWCCD* 140 foot basin. The model was tested at 0, 0.66, 1.29, and 1.96 ft/sec with two different transom submergences in irregular head seas. A wavemaker was used to generate a spectrum of sine waves to produce head seas from Sea State 2 up to high Sea State 4.

1.2. Seabasing

The model used for testing is based on a future concept design for U.S. Navy to use during seabasing. Seabasing is used to extend the network of military maneuvering operations through secure and mobile bases at sea. The Sea Base will be pre-positioned with cargo and therefore not have to enter a foreign nation's port to off-load cargo and personnel. This will lead to expedited deployment and employment during a crisis and will provide Joint Force Commanders with global command and control.[(1)]

Seabasing offers many positive attributes to the military such as assembling troops and equipment at sea, sustaining and reviving fighting forces from the sea, and off-loading specialized cargo for different missions. *FLO/FLO*'s task is to serve as a staging and beach area for *LCAC*s, *EFV*s, cargo, and personnel. *FLO/FLO* is to be loaded by a *LMSR* and serve as a point of deployment for amphibious landing vehicles. These landing vehicles then transport cargo ashore to supply troops based on land. The *MPF(F)* has envisioned the *FLO/FLO* to accomplish multiple sea basing capabilities. The three primary capabilities of the *FLO/FLO* will be to perform skin to skin interface, *LCAC* interface, and vehicle transfer. [(2)]

1.3. FLO/FLO

The design concept being tested is very similar to a heavy lift ship. Full scale at-sea demonstration and testing of the *FLO/FLO* was conducted with a heavy lift ship. A heavy lift ship is a semi-submersible ship that has a large open deck surrounded by a pilot house forward and machinery space aft. Ballast tanks are flooded to submerge the deck below the water surface to load the vessel, and then the ballasts tanks are emptied to raise the deck and its cargo.

Modifications to the heavy lift ship design have led to a specialized *FLO/FLO* to meet specific capabilities. For instance, the transom has been altered to accommodate different types of cargo and vehicle loading with containment berms and fender walls. The ship was designed to have sheltered storage of *EFVs* and cargo in the forward portion of the ship. The aft portion of the ship, behind the entrance to the storage area, is used to carry, transfer, and deploy *LCACs* and *EFVs*.(2)

The model was designed with two lanes aft of amidships that extend longitudinally to the transom for *LCAC* and *EFV* operations. The transom has various stern extension and gate configurations. The stern extension is simply an addition to the length of the ship that has a deck and hull, but has no side walls. In this configuration, no gates are at the stern so water is free to enter into the open well decks.

The other configurations use two stern gates without the stern extension. These gates serve as both a physical barrier to incoming deck wash and a ramp to assist vehicles being deployed and boarding the ship. With these gates, three individual conditions are possible: both gates down, one gate up and one gate down, and both gates up.

In addition, the ship can change drafts by ballasting to provide needed conditions for launch and recovery of vehicles. In this experiment, two ballasting conditions were considered, one for *LCAC* operations and the other for *EFV* recovery.

The design concept was conceived by *MPF(F)* who also administered the full scale at-sea tests. The model and its stern extension were constructed by *CSC* Advanced Marine Center out of Washington, DC. *CSC* also provided information on the desired model configurations including drafts and trim angles.

1.4. Background Full-Scale Testing

Prior full scale at-sea tests of *FLO/FLO* with a heavy lift ship took place in three locations, Ft. Lauderdale, FL, for motion testing, Puget Sound, WA, where the seas are fairly calm for transfer operations, and in the San Diego, CA, for the same type of testing as administered in Puget Sound but in rougher seas.(2) The sea state, defined by the significant wave heights, periods, and character in a body of water, is given on a scale of zero to nine. The standard sea state designation is *NATO STANAG 4194*, the Standardized Wave and Wind Environments and Shipboard Reporting of Sea Conditions. The table below shows an excerpt from the *NATO STANAG 4194*.(1)

	Significant Wave Height (meters)**		**Modal Wave Period (seconds)**
Sea State	Range	Mean	Range
0-1	0-0.1	0.05	-
2	0.1-0.5	0.30	3.3-12.8
3	0.5-1.25	0.88	5.0-14.8
4	1.25-2.5	1.88	6.1-15.2
5	2.5-4	3.25	8.3-15.5
** Significant Wave Height- If all the wave heights (peak to trough) of a wave record are measured, the significant wave height is the mean value of the highest one-third waves.			

Table 1. ***NATO STANAG 4194***

Table 1 displays the full scale values of significant wave heights and modal wave periods for Sea State 5 and below. Tests in Puget Sound were administered between Sea States 0 and 2. In San Diego, tests were administered between Sea States 1 and 4.

Sea testing, to date, has shown that additional tests are needed to define design requirements for the stern of *FLO/FLO* for *LCAC* and *EFV* operations due to deck wash and rolling.[(2)]

The structure of this report is organized as follows. Assumptions are addressed during the *FLO/FLO* testing, followed by a detailed description of the model, apparatus, and the measurement devises used to administer the tests. The entire list of tests performed appears in Appendix 1. Data results and observations are discussed regarding seakeeping, deck wash, and flow around the transom. Finally, conclusions are made along with recommendations.

2. Assumptions

2.1. Froude Scaling

Froude Scaling was used because the dominating effects on the model were gravity based not viscous. The corresponding speed is related to F_n through a scaling factor. The following equation was used to determine the velocities at which the model was tested.[3]

$$V_M = V_s \sqrt{\frac{L_M}{L_s}} \tag{1}$$

2.2. Wave Spectra

To collect data in the irregular waves, the spectral analysis approach was used. This interpretation of irregular waves shows that the sea is an accumulation of sine waves of different energies, frequencies, and directions. While testing the model in irregular waves, it was assumed that a scaled 30 minutes of data for each test was sufficient to provide a statistically valid result and represent actual irregular sea conditions for future ship operations.

2.3. Tow Tank

The tow tank facility used to test the *FLO/FLO* model is 140 ft in length, 10 ft in breadth, and has a water depth of 4 ft. The model was limited to a useful run length of 50 ft at constant velocity due to start and stop time. An assumption was made that the test facility's size did not create boundary conditions too large to disturb the data collected by inducing boundary layer effects or interfering with wave resistance. Also, it was assumed that the waves reflecting off the back of the basin were being dampened by sloped honeycomb sheets which had much less energy and could not interfere with the new waves approaching the model.

The model provided by *CSC* is sized properly for the 140 foot tow tank, not exceeding the depth Froude number of 0.6, avoiding interference with the walls and bottom of the tank. The mid-ship cross sectional area of the model should not exceed about 1/200th of the basin's cross sectional area in order to avoid setting up appreciable return flow in the water around the model, the so-called blockage effect.[3]

Tests were administered to check the amount of error related to the reflection of these waves. A set of waves was released and allowed to reflect off the end of the tank and return towards the model. Results showed a noticeable amount of reflection off the back wall. These reflected waves proved to be approximately 84% lower than the original seas. Due to their velocity, the reflected waves would only slightly affect the model during the 0.66 ft/sec tests. These effects were minimal, and wave reflection was neglected.

3. FLO/FLO Model

3.1. Model Characteristics

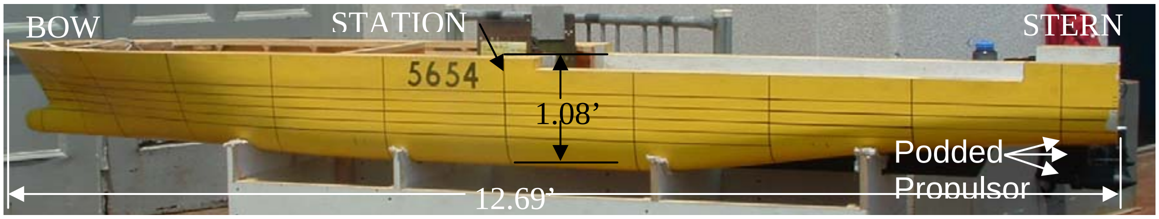

Figure 1. Model Profile

A 1:60 scale model of the *FLO/FLO* was used for tests in the *NWSCCD* 140 foot basin and is shown in Figure 1. The model represents a 761.4 ft *LOA* heavy lift ship. As seen in Figure 1, the model's *LOA* is 12.69 ft with a beam of 2.35 ft and depth of 1.08 ft from the keel to the main deck at amidships, station 10. The forward decks are not on the model during the testing to allow for weights to be shifted attaining desired ballasting conditions. The water tight deck aft of amidships drops down to a distance of 9 inches above the keel. The aft deck is split into two open well decks with a center separator of 4 inches in height. At the transom, two gates are used to control the water flow in the well decks during operations.

There are two sets of gates used on the model for the tests without the extension depending on the specific gate configuration needed. Both sets are made of aluminum but one set is comprised of rectangular aluminum flat sheets that are $11\frac{1}{4}$" x $4\frac{5}{8}$" x $\frac{1}{16}$", while the others are $10\frac{1}{8}$" x $6\frac{1}{2}$" x $\frac{1}{16}$" aluminum sheets bent at negative 20 degrees from the horizontal to act as ramps in the open position.

There is enough room on the deck to store two columns of *LCACs*, six total. There is a sand strip around the bulbous bow to generate turbulent flow. The model is also installed with three generic podded propulsors to generate a more representative flow to that of the full scale vessel.

Figure 2 shows the aft end of the model with the water tight decks in place and both of the gates in the down position allowing water to enter the well decks. The black stripes on the decks were used to measure the water entry length. They are spaced 1 inch apart and continue 62 inches towards the bow. In this configuration, the gates can both be down, as shown or one gate up while the other is down allowing water to enter into one well deck only.

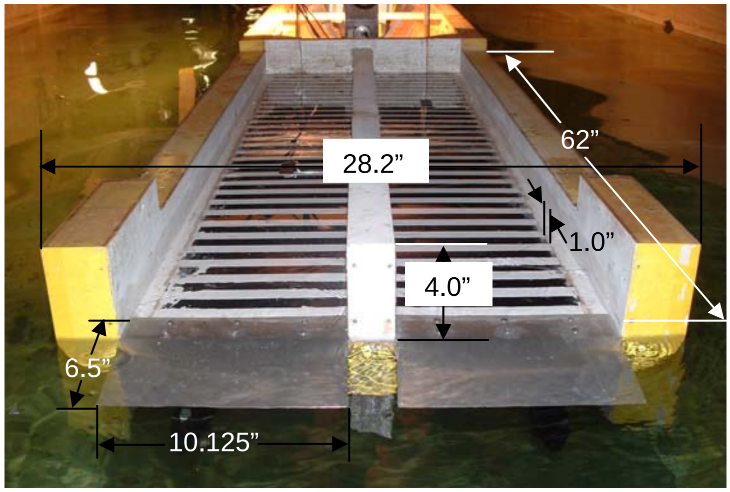

Figure 2. Aft view of model with gates

The model is equipped with an option to connect a stern extension to the transom altering the hull configuration. The extension increases the model *LOA* by 10 inches. The extension slopes downward to act as a beach on which aircushion or amphibious vehicles can board the vessel, but there are no side walls or gates on the extension to resist green water. With this stern configuration, water freely enters the well decks and can submerge the extension at larger trim angles and drafts. This is shown in Figure 3.

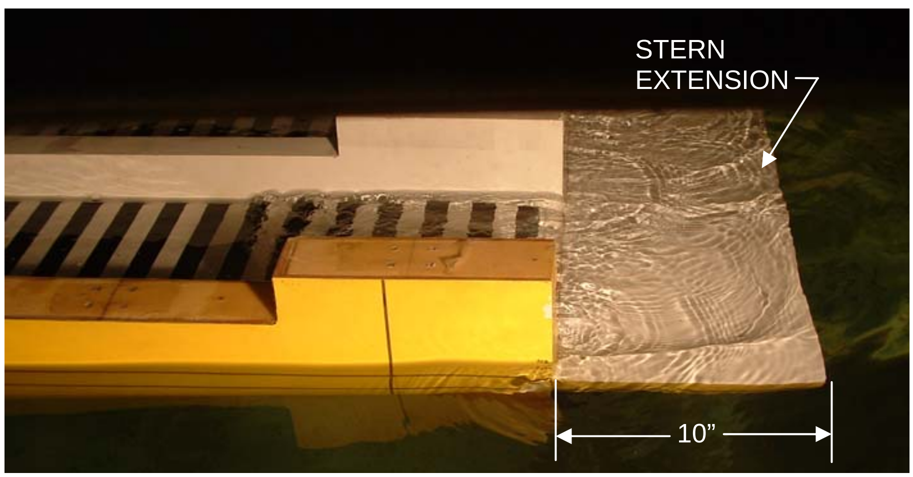

Figure 3. Model with Stern Extension On

3.2. Stability

The *FLO/FLO* concept was tested at two main ballasting conditions associated with the launch and recovery of *LCACs* and *EFVs* for the purpose of determining the extreme values of seakeeping capabilities. The *FLO/FLO* concept also has two different hull configurations associated with or without the stern extension. Vehicle launch and recovery onto the ship is conducted by reducing the speed and ballasting the ship until the depth of the transom is low enough for the vehicles to board. With the stern extension, vehicles would gain access to the ship by first accessing the large deck or platform located at the stern. From this point the vehicles would need to traverse up the remainder of the sloped extension deck and through the gates located at the end of the loading bay.

The second configuration has no sloped deck associated with the stern. This would require the gates on the rear of the loading bay to act as ramps, which when lowered into the water would allow access for the *LCAC* and *EFV* vehicles to gain access to the loading bay.

The model represented the full-scale mass properties as well as geometry. Initial values of *LCG*, *VCG*, and displacement for the full sized ship and each ballasting condition of the model were needed to determine a starting point to calculate moments of inertia and periods for pitch and roll. Rhinoceros® surface modeling software was used as a first estimate of these values for the ship and model, which are shown in Appendix 2, Table 9. Using a swing frame, weights were added to match the model mass characteristics. An inclinometer with an uncertainty of ± 0.1 degrees was used to read the angles during the swing tests which were then used to calculate moments of inertia and model traits. The model properties are the difference between of the system values and swing frame values. The Z_{sys} was derived using the angles produced by the placement of a small weight at various locations on the frame as shown in the following equation:

$$Z_{sys} = \frac{w}{W_{sys}}\left(\frac{x_w}{\tan(\alpha - z_w)}\right) \tag{1}$$

Using Z_{sys} from the above equation, Z_M was calculated.

$$Z_M = \frac{Z_{sys}W_{sys} - Z_f W_f}{W_M} \tag{2}$$

The *VCG* was found from the results of the previous two equations for each ballasting condition.

$$VCG = BL_{ref} - Z_M \tag{3}$$

The roll and pitching moments of inertia was found by oscillating the model in a single degree of freedom as it was connected to the swing frame. By determining the period in each case the following equations were used to calculate the moments about the pivot axis, station 10 on the model.

$$I_T = W_{sys}Z_{sys}\left(\frac{T_{sys\_roll}}{2\pi}\right)^2 - W_f Z_f\left(\frac{T_{f\_roll}}{2\pi}\right)^2 \tag{4}$$

$$I_L = W_{sys} Z_{sys} \left(\frac{T_{sys\_pitch}}{2\pi} \right)^2 - W_f Z_f \left(\frac{T_{f\_pitch}}{2\pi} \right)^2 \tag{5}$$

The final moments were calculated by shifting the above results to the model center of gravity.

$$I_R = I_T - \frac{W_M}{g} Z_M{}^2 \tag{6}$$

$$I_P = I_L - \frac{W_M}{g} Z_M{}^2 \tag{7}$$

Once the weights were in the proper locations for each ballasting condition, the model was placed in a small drop tank to determine the metacentric height by slightly shifting weights to achieve the correct forward and aft drafts for each condition while still closely matching the *VCG*, *LCG*, pitch and roll. This model test required trim angles for all *LCAC* conditions to be approximately -0.5 degrees and *EFV* conditions to be -1.5 degrees.

The inclinometer was again used to read the degrees of roll for the model in the drop tank. With these angles, Equation 8 was used to calculate the GM for each inclinometer reading. To create the small roll angles, a small weight was placed on the edge of the model on the port and starboard sides.

$$GM = \frac{w}{w + W_M} \times \frac{x}{\tan|\alpha - \alpha_o|} + z - VCG_{AboveBL} \tag{8}$$

The average GM was collected and used to check the model's stability by equating the righting arm, *GZ*, in Equation 9, where ϕ is the heel angle.

$$GZ = GM \sin\phi \tag{9}$$

This information shows that if *G* is below *M* then *GZ* is positive and the model is stable[3]. Table 2 below shows the results found for the model during testing and those found from hydrostatics. The conditions without the extension use data with the gates both open for calculations. In each case, *GM* is positive meaning that the model is stable at all conditions. Details can be found in the Appendix 2, Table 9 and Table 10 .

	EFV no Extension	LCAC no Extension	EFV w/ Extension	LCAC w/ Extension
GM Hydrostatics (ft)	0.64	0.60	0.64	0.63
GM Testing (ft)	0.47	0.70	0.49	0.72

Table 2. Table of GM results for model

All of the conditions are found to have similar results in stability. The results show that the model tested with the extension on is more stable in both ballasting conditions than with the gates in place, and the hydrostatic calculations show the opposite. The hydrostatic calculations were estimates to initially place ballasting weights in the model for swing testing.

3.3. Model Configurations

3.3.1. EFV Recovery with Stern Extension

The *EFV* Recovery Ballasting Condition is associated with the retrieval of *EFVs.* The *EFV* recovery loading condition is the heaviest of the ballasting conditions associated with the *FLO/FLO.* During this loading condition, water is fully covering the transom extension and, in calm water, submerges almost half the two well decks. Figure 4 shows the *EFV* condition in Sea State 4 at zero velocity. The weight of this condition is 971.37 ± 1 lbs with a stern down trim of 1.51 degrees. The trim was found from the T_{AFT} of 0.83 $\pm$ 0.005 ft and T_{FWD} of 0.48 ± 0.005 ft. The weight placements can be seen in Appendix 3, Figure 26.

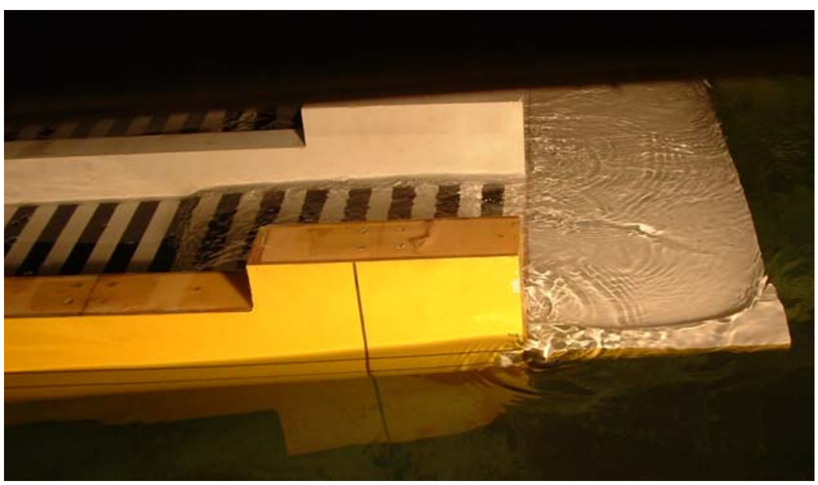

Figure 4. *EFV* Recovery with Stern Extension in Sea State 4 Zero Velocity

For this stern and ballast configuration, strip theory hydrostatic calculations were made based on offsets from Rhino software. These values were then used to determine ship hydrostatics.

EFV Recovery		Extension On
Volume	**ft^3**	14.25
KB	**ft**	0.37
I_{xx}	**ft^4**	9.25
BM	**ft**	0.65
KM	**ft**	1.02
LCB +aft FP	**ft**	7.13
A_{wp}	**ft^2**	21.05

Table 3. Table of Strip Theory Hydrostatic Calculations Based On Rhinoceros® Offsets for *EFV* Recovery with Extension

These results aided the ballasting process and determining actual test results. The data can be compared to the other model configurations in Appendix 2, Table 9.

3.3.2. EFV Recovery with Gates

EFV recovery with the gates on creates the greatest amount of water in the well decks of the hull configurations tested. Without the stern extension on, the vessel must increase its draft to let more water enter the well decks. This is necessary to have a sufficient beaching area for the recovery of amphibious vehicles. In Figure 5, the model is shown in calm water without any gates in place. This shows the distance the water has entered the well decks at zero velocity.

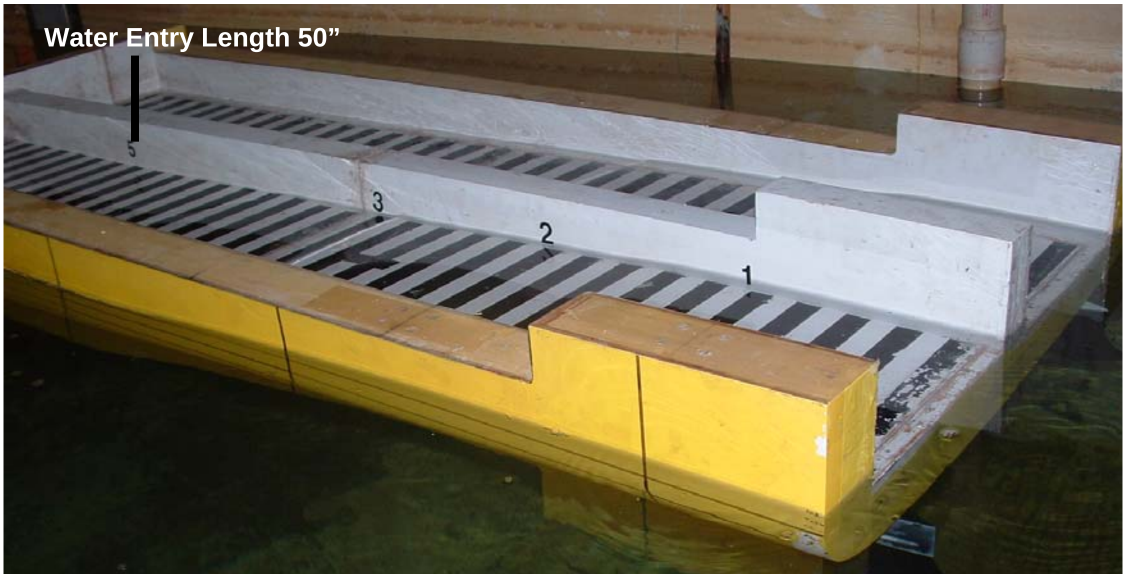

Figure 5. *EFV* Recovery No Stern Extension in Calm Water

The model has a weight of 910 $\pm$ 1 lbs, a T_{AFT} of 0.87 $\pm$ 0.005 ft, and a T_{FWD} of 0.61 $\pm$ 0.005 ft. This created a trim of -1.15 degrees, which is less than the desired -1.5 degrees. A higher volume of water would be present in the well decks of the model if the model were actually trimmed at -1.5 degrees than at the tested -1.15 degrees.

Table 4 shows the theoretical hydrostatic calculations based on the Rhinoceros® offsets that were used to predict weight locations for ballasting and to determine the seakeeping results after testing the model in the basin.

EFV Recovery		Gates Closed	Gates Open	Gates Split
Volume	**ft^3**	14.93	14.58	14.76
KB	**ft**	0.40	0.40	0.40
I_{xx}	**ft^4**	10.53	8.42	9.48
BM	**ft**	0.71	0.58	0.64
KM	**ft**	1.11	0.97	1.04
LCB +aft FP	**ft**	6.82	6.72	6.77
A_{wp}	**ft^2**	24.94	18.26	21.60

Table 4. Table of Strip Theory Hydrostatic Calculations Based On Rhinoceros® Offsets for *EFV* Recovery No Extension

Each gate configuration has slightly different values due to the amount of water that is on deck and the roll that it induces which will change the waterplane area. As more water settles on the deck, the *LCB* moves forward slightly and reduces the *KM* and *BM.* This will change the stability results for each gate configuration.

3.3.3. LCAC Operations with Stern Extension

The *LCAC* condition was tested with the stern extension and with no stern gates or water on the deck in the calm water condition at zero velocity. The negative longitudinal slope of the stern extension seen in Figure 6 aids in *LCAC* loading operations by creating a sloped beach to drive on and off the *FLO/FLO*.

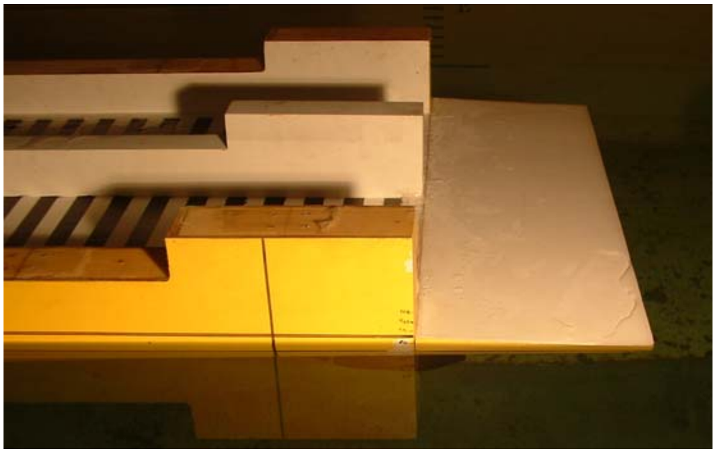

Figure 6. *LCAC* Condition with Stern Extension

The model has a T_{AFT} of 0.72 ± 0.005 ft and a T_{FWD} of 0.55 ± 0.005 ft creating a trim angle of -0 .77 degrees, more than the desired -0.5 degrees. The error involved with weight placement created an error in the trim angle which is slightly more extreme than the desired -0.5 degrees. The extension adds a great amount of buoyancy and 10 inches of length to the model which decreases the overall draft and shifts the *LCG* further aft of the *COG*, than without the extension. The model has a weight of 929 ± 1 lbs. The weight placements for this configuration can be seen in Appendix 3, Figure 28.

Table 5 shows several of the model characteristics computed from Rhinoceros® for this specific ballasting condition. These values were used as approximations to set up the weight distribution in the model, which lead to the test values. The test results can be found in Appendix 2, Table 9 along with the results from the testing in Table 10. Those results are not exactly equal to the starting hydrostatic values seen in Table 5.

LCAC Operations		Extension On
Volume	**ft^3**	14.28
KB	**ft**	0.38
I_{xx}	**ft^4**	11.59
BM	**ft**	0.81
KM	**ft**	1.19
LCB +aft FP	**ft**	6.81
A_{wp}	**ft^2**	27.37

Table 5. Table of Strip Theory Hydrostatic Calculations Based On Rhinoceros® Offsets for *LCAC* Ops. With Extension

These theoretical results were used to find the model's stability characteristics and compared to the actual values measured. With the extension on, the waterplane area is increased as are the *BM*, *KM*, and *Ixx*.

3.3.4. LCAC Operations with Gates

This *LCAC* loading condition is the lightest of the ballasting conditions associated with the *FLO/FLO*. During this loading condition, a small amount of water on deck was present that only reached the aft edge of the main deck in calm water at zero velocity allowing the *LCACs* to access the platform or rear gates without any hindrances. In this condition, the model weighed 897 ± 1 lbs. This is less than the previous *LCAC* condition because there is no stern extension adding extra buoyancy to the model. Therefore, the model needs less weight and different drafts, a T_{AFT} of 0.77 ± 0.005 ft and a T_{FWD} of 0.66 ± 0.005 ft, to reach a similar trim angle. Due to the error involved in weight placement in the model, the trim by the stern is 0.48 degrees. The weight placements for the *LCAC* operations with gates on and the test results that used the Rhinoceros® offsets can be seen in Appendix 3, Figure 29 and Appendix 2, Table 9 respectively.

There are three gate configurations tested in this condition, both gates down, one gate up while the other is down, and both gates in the up position. Each one of these configurations alters the hydrostatic properties slightly. In this case, there is very little difference between the gate configurations because the calculations are completed in calm water at zero velocity which means very little water is present in the well decks to change the hydrostatic properties of the model. Table 6 shows the Rhinoceros®

hydrostatic results used to approximate the weight placements for the desired trim angle and draft for each gate configuration.

LCAC Operations		**Gates Closed**	**Gates Open**	**Gates Split**
Volume	**ft^3**	14.75	14.75	14.75
KB	**ft**	0.40	0.40	0.40
I_{xx}	**ft^4**	10.70	10.70	10.70
BM	**ft**	0.73	0.73	0.73
KM	**ft**	1.13	1.13	1.13
LCB +aft FP	**ft**	6.52	6.52	6.52
A_{wp}	**ft^2**	25.36	25.36	25.36

Table 6. Table of Strip Theory Hydrostatic Calculations Based On Rhinoceros® Offsets for *LCAC* Ops. without Extension

4. Test Facilities

4.1. 140 Foot Basin

The 140 Foot Basin at *NSWC* Carderock is 140 ft long, 10 ft wide, and has a depth of 5 ft. The water depth in the basin was at a constant 4 ft throughout the testing. At the end of the tank there is a beach built to dissipate wave energy generated by the wavemaker at the opposite end of the tank. The beach uses the decreasing depth of the tank and corrugated sheets to dampen the currents in the basin. The wave absorbers are constructed of two variable slope honeycomb sheets, 6 inches x 48 inches x 120 inches with 0.25 inch cell openings, which span the width and depth of the tank (4).

At the other end of the tank is a flap type wavemaker pinned to the bottom of the tank by hinges, which allows the flap to rotate. The flap is an aluminum sheet that spans the width of the tank and stands 6 ft high. Behind the flap is damping material, floating objects and netting, to damp out wave motion in the area between the flap and the start wall. A computer with LabVIEW 7.1 and a wave generating program, written by John Hamilton from *NSWCCD* Code 50, was used to control the wave patterns created by the wavemaker and the run time. Table 7 shows the inputs used to operate the wavemaker at Sea States 2 and 4. The specific dimensions are specified within the program if they are not shown in the table.

Wavemaker Input										
	N	f1	f2	Tm (modal Period)	Significant Waveheight	Actuator Sensitivity	Distance (ft)	Water Depth (ft)	H/S
SS2	50	0.001	5.65	0.9	1	0.8	6	4	2
SS4	50	0.001	5.65	1.16	3	0.8	6	4	0.7

Table 7. Wavemaker Inputs

4.2. Carriage

The model was towed by the carriage installed in the test facility. As seen in Figure 7, the carriage is comprised of mostly I-beams that span the width of the basin and is 13.7 ft long. On the left side of the basin, two wheels and four other roller pairs guide the carriage on the main rail. On the opposite side of the basin, two weight bearing wheels move on a flat rail. The carriage can be set to run in either direction in the tank (4).

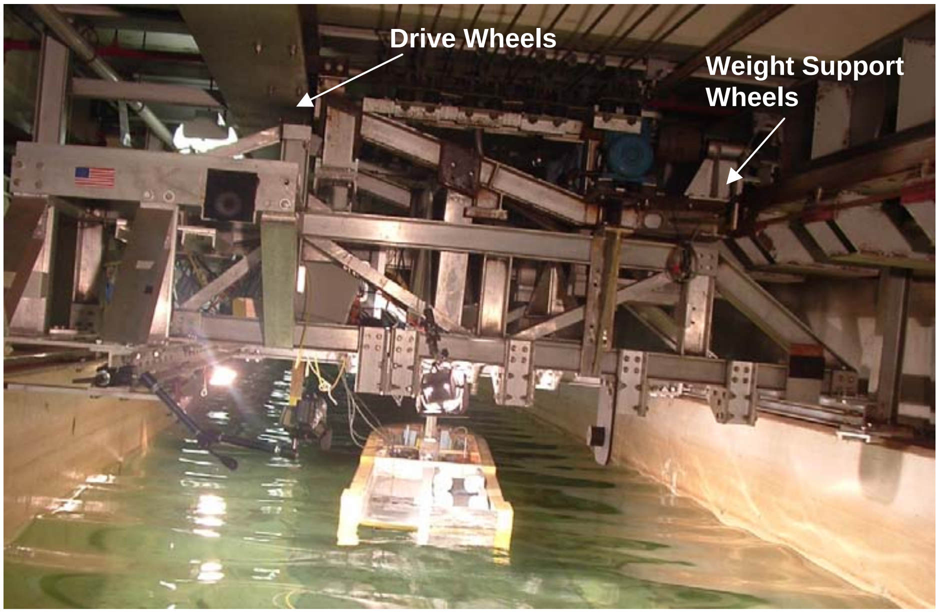

Figure 7. 140' Basin

The *FLO/FLO* model was attached to the carriage with a heave staff assembly that was clamped to the beam structure of the carriage, shown in Figure 8. The heave post was attached to the model by the means of a pitch/roll gimbal assembly located at the model's *LCG*. The heave staff passed through bearings that allowed the model to heave freely. The heave staff was directly connected to a 4 inch block gauge which would provide the forward drag force on the model. The data collection system used for the test was located completely on the sub-carriage and was strapped down to the carriage beams to keep everything secure while the carriage was in motion.

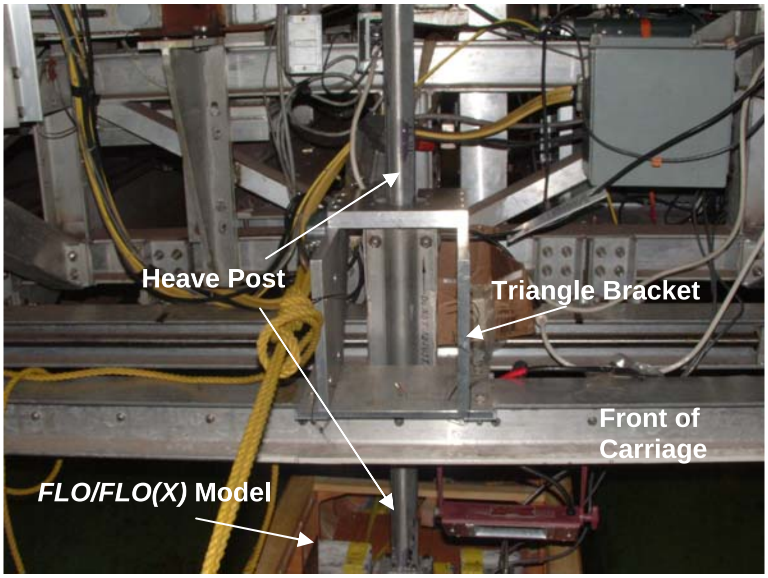

Figure 8. Model Connection to Carriage

The carriage would initially jolt the model at the start of a test, creating uncharacteristic motions and oscillations in the longitudinal plane as detected by the data collection system. These oscillations were quickly dampened by the water and towing apparatus, allowing these oscillations to be filtered out during analysis.

The useful testing length in the basin for this model was approximately 50 ft in order for the carriage to reach a constant velocity and stop at the end of a run. The carriage was limited to a minimum velocity of 0.65 ± 0.02 ft/sec and a maximum of 10.3 ± 0.02 ft/sec. The minimum speed was used to test the model at a 1:60 scaled 3 knots or 0.66 ft/sec. The maximum speed used during this testing period was a 1:60 scaled 12 knots, 2.61 ± 0.02 ft/sec.

5. Electronics

The basic set of seakeeping data channels was recorded electronically. These consisted of drag, pitch, roll, heave, *COG* accelerations, wave height, and carriage speed. Appendix 4: Calibrations displays a flow chart of the electronics used during the model testing and the channel list including calibration details.

5.1. Collection Computer

The data collection system used a desktop computer, 233 MHz Pentium CPU, 63 MB RAM, running a Microsoft Windows 95 operating system. The data collection software, Figure 9, was developed by *NSWCCD*, designated as COLAM, Ship Motion Recorder Collect Program. Associated with the data collection computer was an *NSWCCD* manufactured 12-bit analog-to-digital converter along with Frequency Devices 5016 filter chassis housing D68L8D low-pass filters with a cut-off frequency of 2 Hz shown in Figure 10.

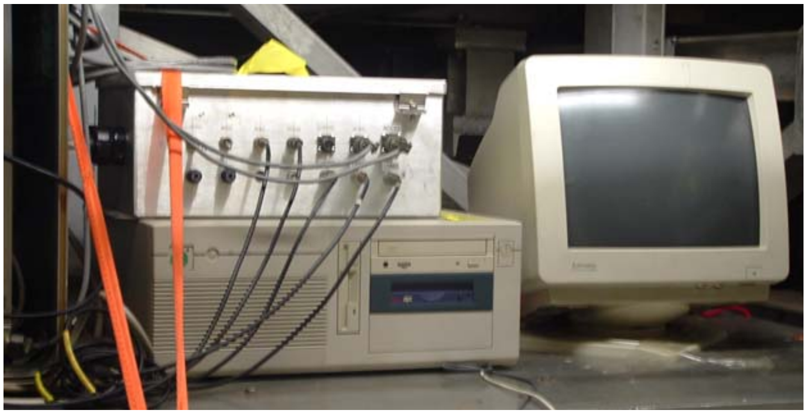

Figure 9. Collection Computer

Figure 10. Analogue to Digital Converter

5.2. Tri-Axial Accelerometer

Longitudinal, transverse, and vertical accelerations of the model were measured by a Columbia SA-307HPTX tri-axial accelerometer unit with a 1G counter bias on the vertical axis shown below. The power source was from a +/- 15 VDC Acopian power supply. The channels followed the right-hand convention for polarities and was placed on the centerline, 8 inches forward of amidships. The accelerometer was bench calibrated according to *NSWCCD* standard practice, using the *NSWCCD* Code 5500 tilt table.

Figure 11. Tri-Axial Accelerometer

5.3. Gyroscope

The roll and pitch motion of the model was measured by a Humphrey VG34 vertical gyroscope installed 3 inches aft of amidships. The vertical gyroscope was bench calibrated according to *NSWCCD* standard practice, using the *NSWCCD* Code 5500 tilt table.

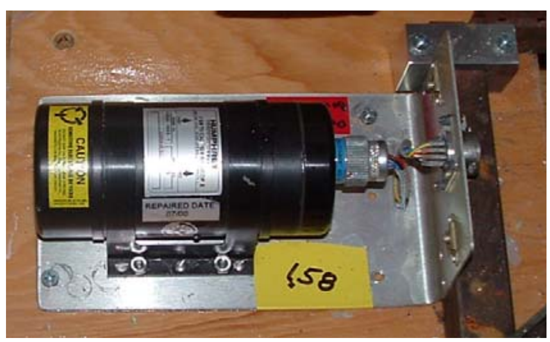

Figure 12. Humphrey Gyroscope

5.4. Block Gauge

Resistance was measured by a block gauge placed directly on top of the gimbal shown in Figure 13. The 4 inch block gauge used was a 50 lb gauge conditioned through a Validyne CD19 carrier demod. The block gauge was calibrated in the *NSWCCD* Code 5200 calibration lab on the dynamometer calibration stand.

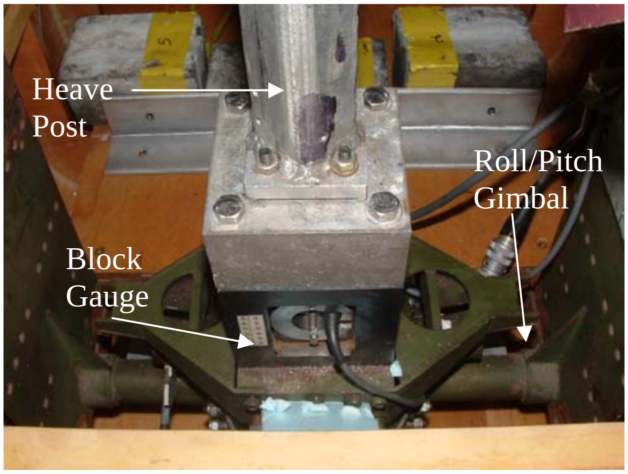

Figure 13. Block Gauge

5.5. Wave Height/ Heave Sensor

The wave height and heave of the model were measured using a Senix ULTRA-S type ultrasonic sensor, which provides non-contact ultrasonic measurement of distances. The Senix ultrasonic sensors were powered by a 28 VDC Acopian power supply. The Senix ultrasonic sensors were setup using the WinSpan for Windows software package, which allows the user to configure the sensor output.

Figure 14. Wave Height Sensor

5.6. Velocity Sensor

Carriage speed was measured by an optical encoder located on one of the wheels attached to the main rail of the carriage assembly which provided the pulse signal into an *NSWCCD* manufactured frequency-to-voltage converter. The calibration factor for carriage speed was provided by the facility group based on the encoder output pulses.

6. Results and Discussion

6.1. Water Entry

Throughout testing, water entry length into the well deck was of interest. Depending on the stern configuration and ballasting conditions, water would enter the aft end of the model and submerge portions of the well decks. For *LCAC* operations, water does not need to be present in the well decks. A *LCAC* can clear 4 ft obstacles; therefore, it can launch and recover if the transom is not submerged. For *EFV* launch and recovery, the *FLO/FLO* is required to trim by the stern. The vehicles are to float on and off the *FLO/FLO* and cannot be interfered by the transom to avoid damage. This requires water be present in the well decks for this operation.

All conditions were tested in both Sea State 2 and 4 irregular head seas. Focus was concentrated on the data from Sea State 4 conditions because, after observing and reviewing data, there were no concerns in any operations during Sea State 2 tests. Cameras were placed on the port side of the well decks and aft of the model to capture water entry lengths. All results were positive and the model was completely operable in the conditions tested. The following results and discussion for water entry length are regarding Sea State 4 irregular head seas with the extension on, both gates down, or split (with one gate down and on gate up).

6.1.1. *LCAC* Operations

During *LCAC* Operations, with the stern extension on, there was a negligible amount of water entering into the well decks at zero velocity. While the model was in motion, water wetted the stern extension and less than 10% entered the well decks as shown in Figure 15.

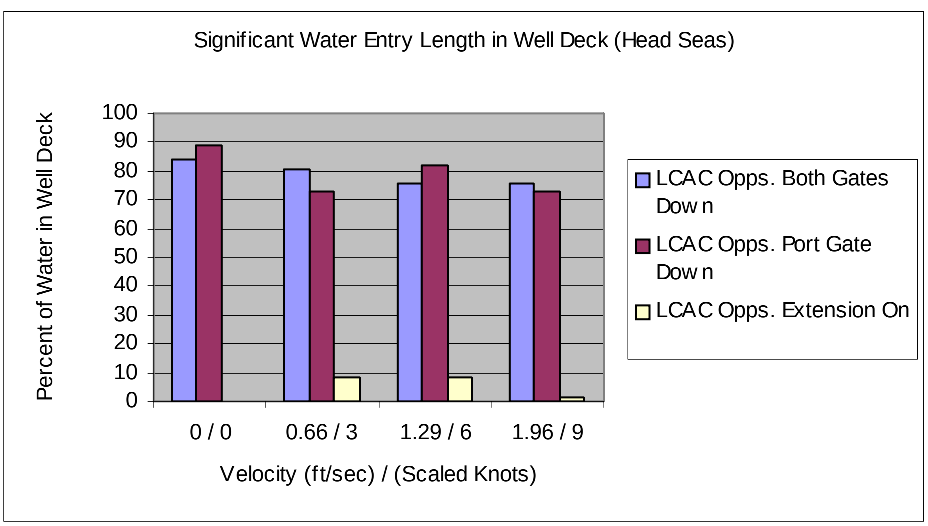

Figure 15. Significant Water Entry Length in Well Deck (*LCAC* Operations)

However, these results changed with the removal of the stern extension. With gate configurations both down and split, there was significant water entry into the well decks. This stern configuration resulted in between 70% and 90 % of the deck's overall length being wetted. Water entry lengths are also influenced by symmetry of the gate configuration. Tests with the stern extension on and with both gates down yield fairly consistent water entry lengths for each velocity as shown in Figure 15. The maximum entry length occurred at zero velocity.

At a small trim angle and zero velocity the model had a high range of pitching motions allowing water to be "scooped" into the well decks. Since the gravity component acting on the water inside the well decks is smaller than at a higher trim angle, the water inside the well decks was able to move freely occasionally impacting the bulkhead at the end of the well decks.

With a considerable amount of water moving uncontrollably inside the well decks during this *LCAC* ballast condition, operations such as loading and unloading LCACs, operating vehicles and movement of personnel must cease due the hazardous conditions present within the well decks.

The results show that the model with the extension on is more effective in controlling the model motions and water entry than without for *LCAC* operations. There is less water on deck allowing operations to occur while in the ballasted condition and less risk for damage to other craft, cargo, and people on deck.

6.1.2. *EFV* Operations

During *EFV* recovery with the extension on, between 40% and 45% of the deck was wetted. Approximately 81% of the well decks was wetted without the stern extension during both gate configurations, down and split, as shown in Figure 16. The gate configuration or velocity of the model did not alter the water entry lengths creating more consistent results than those for the *LCAC* operations testing.

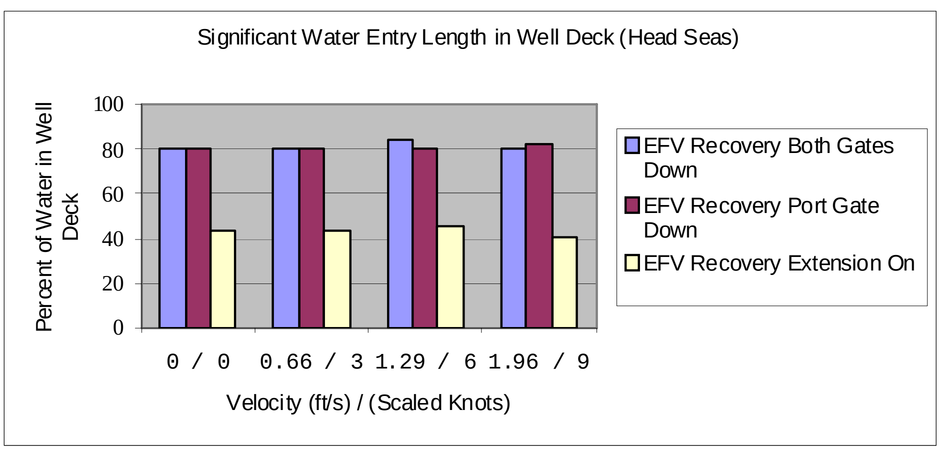

Figure 16. Significant Water Entry Length in Well Deck (*EFV* Recovery)

EFV recovery allows for more effective deck operations with the stern extension on than with the gates split or down, minus the stern extension. Water was only traversing half of the deck with the stern extension allowing the remaining dry portion to be used during operations while in this ballasted condition. Without the stern extension, operations must cease due to hazardous conditions produced by the water inside the well decks.

The presence of a stern extension greatly reduces the water entry lengths within the well decks for both *LCAC* and *EFV* conditions. The stern extension increased the overall length of the model, added additional buoyancy to the model, created sufficient launch and recovery environments, and decreased the water traversing the deck.

6.2. Water over Freeboard

While in Sea State 4 irregular head seas, the model was experiencing waves that were of greater amplitude than the freeboard. Aft of amidships, the model in both cases were trimmed by the stern which reduced the freeboard of the model at the transom by 2 inches. In this area, between amidships and the transom, waves were constantly near the top of the side walls lining well decks and would occasionally reach over the side walls. This phenomenon was captured by a side camera placed on the port side of the aft well decks. Figure 17 shows a still shot taken during an *EFV* recovery test without the stern extension and the port gate down with the model moving at a velocity of 1.29 ft/sec. The water reached over the side wall but did not enter the well deck. *EFV* conditions without the stern extension appear the most likely to experience water over the side walls. However, this occurred less frequently during *LCAC* operations without the stern extension. With the stern extension on for both cases, zero water reached over the side walls.

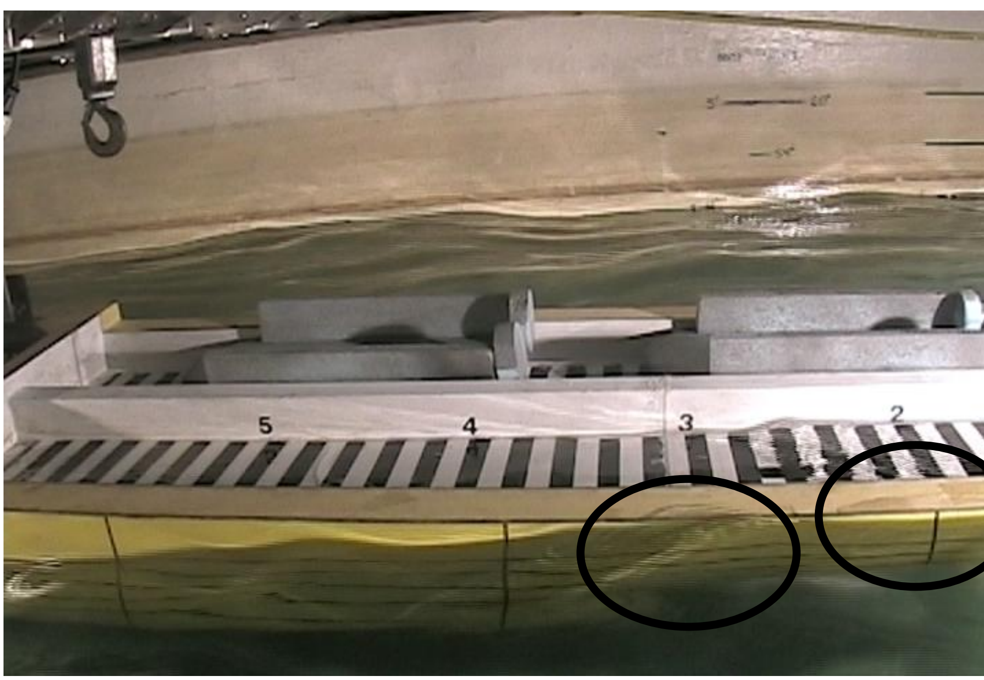

Figure 17. Water over Freeboard

6.3. Seakeeping

To determine the seakeeping characteristics of the *FLO/FLO* model, roll and pitch were measured. Each stern configuration and ballasting condition yielded unique results. Both the *LCAC* operations and *EFV* recovery conditions were tested and compared with the stern extension on, both gates down, and for the port gate down in Sea States 2 and 4 irregular head seas. Sea State 2 results show excellent expected results. There are no concerns for any of the conditions tested in Sea State 2. The following data and discussions will be related to all Sea State 4 conditions because this condition was the most informative. Tables showing the maximum, minimum, mean, standard deviation, normalized values, and average difference for each condition for both pitch and roll can be seen in Appendix 5: Seakeeping along with plots for each of the test conditions.

For the *EFV* conditions, the ideal stern configuration varies with velocity when compared to roll as displayed in Figure 18. The figure compares the maximum degree of roll for each stern configuration at four velocities. The maximum degree of roll was established by taking the normalized difference from the mean for each stern configuration. The zero velocity tests produced the least and most amount of roll for *EFV* recovery.

Figure 18 also shows that as velocity increases, the maximum roll encountered for the port gate down condition decreases. This is opposite for the extension on case, which is worst at 1.96 ft/sec. With both gates down, the results do not display a pattern related to change in velocity, the results are best at the two extreme velocities tested, and slightly worse at 0.66 ft/sec.

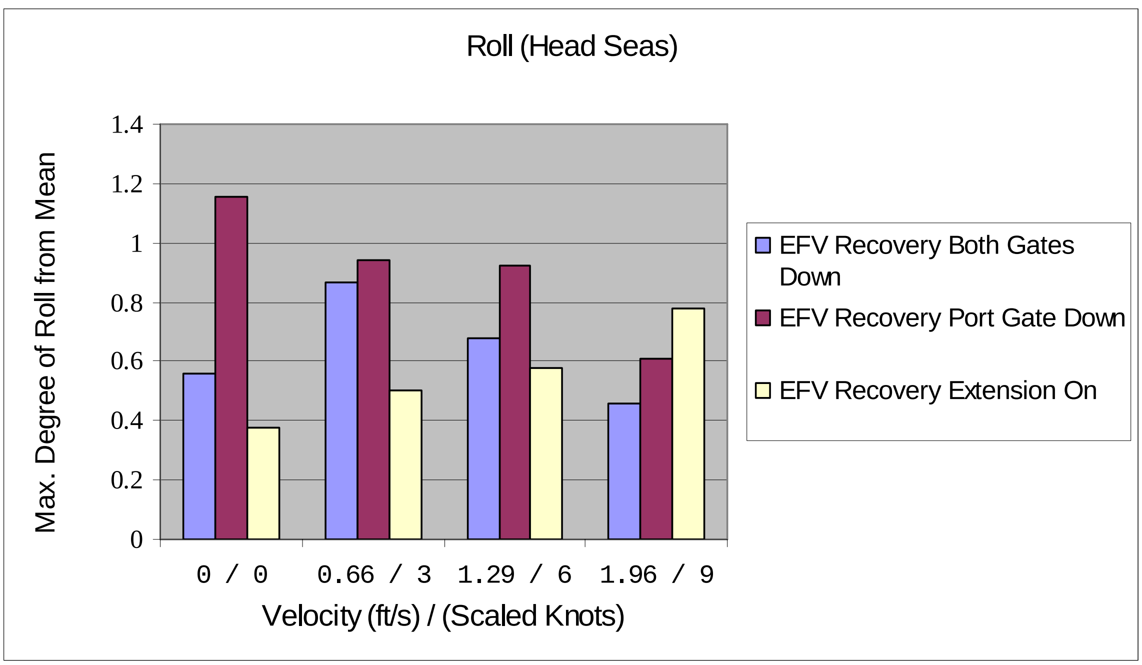

Figure 18. *EFV* Roll in SS4 Head Seas

The *LCAC* data for maximum degree of roll from the mean show different patterns for each velocity tested. Excluding roll at zero velocity, all stern configurations show consistent values across the velocities tested in Figure 19. All values are between approximately 0.6 degree and 0.8 degree, excluding the zero velocity case. Even though the values related to velocity are similar, there is a slight increase in degree of roll as speed increases with the stern extension on until 1.96 ft/sec where the roll begins to decrease. As for the other two stern configurations, the roll values tend to alternate between increasing velocities. They are higher at zero velocity, then decrease at 0.66 ft/sec, then increase again at 1.29 ft/sec, and then again decrease at 1.96 ft/sec. This shows that *LCAC* operations are very consistent in the amount of roll regardless of gate configuration and velocity, the exception being zero velocity.

The roll results are consistent to the results of water entry length. There is not a large difference in the amount of water entering the well decks between stern configurations; therefore, the gate configurations do not alter the roll the model is experiencing.

At zero velocity, the data shows different trends. This is due to the fact that more water is on deck at zero velocity than at speed as addressed in Section 6.1.1. Therefore, the water on deck is influencing the roll of the model. The best condition is with the stern extension on at zero velocity. The worst condition for roll is at zero velocity with the port gate down; it more than triples in value.

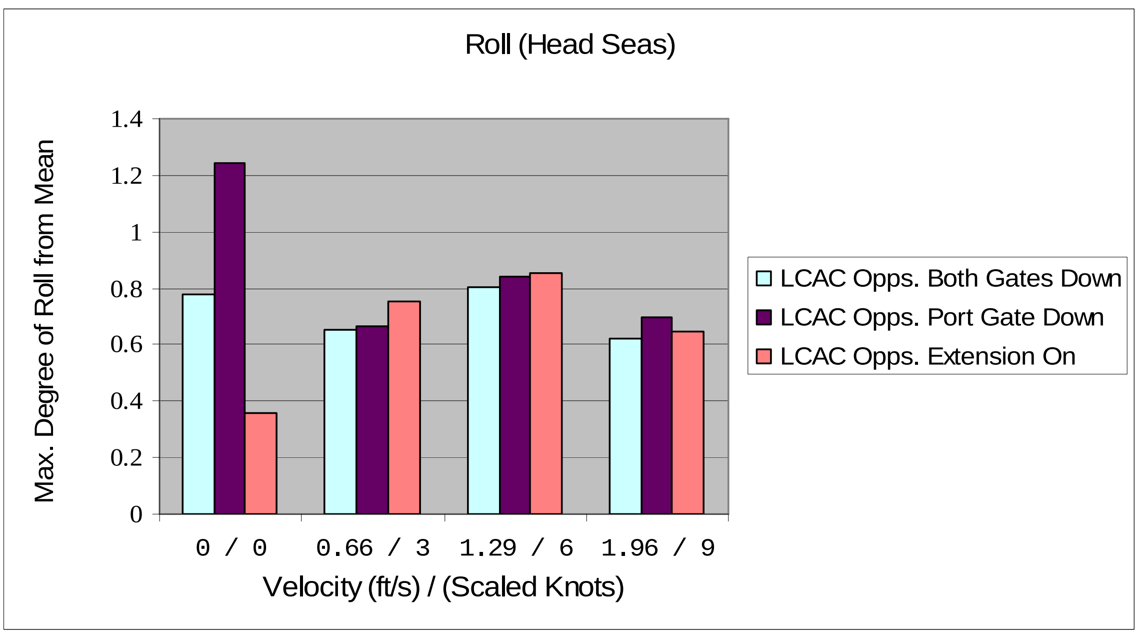

Figure 19. *LCAC* Roll in SS4 Head Seas

At zero velocity, the roll is minimized with the extension on for both the *EFV* and *LCAC*. For *EFV* recovery, the extension is the better stern configuration for the model. Data shows that the extension results are most favorable at all velocities except at 1.96 ft/sec, which is too great of a speed and not likely to be used to recover *EFVs*. For *LCAC* operations, the extension on resulted in slightly higher degrees of roll at speed, but all the values are very similar and the increase will not affect operations much more than other stern configurations. If gate configurations are used, opening only one well deck gate will greatly increase the roll for *EFVs* since one well deck will be filled with water and not the other. Figure 20 combines the two previous bar graphs to show the comparison between the ballasting conditions analyzed.

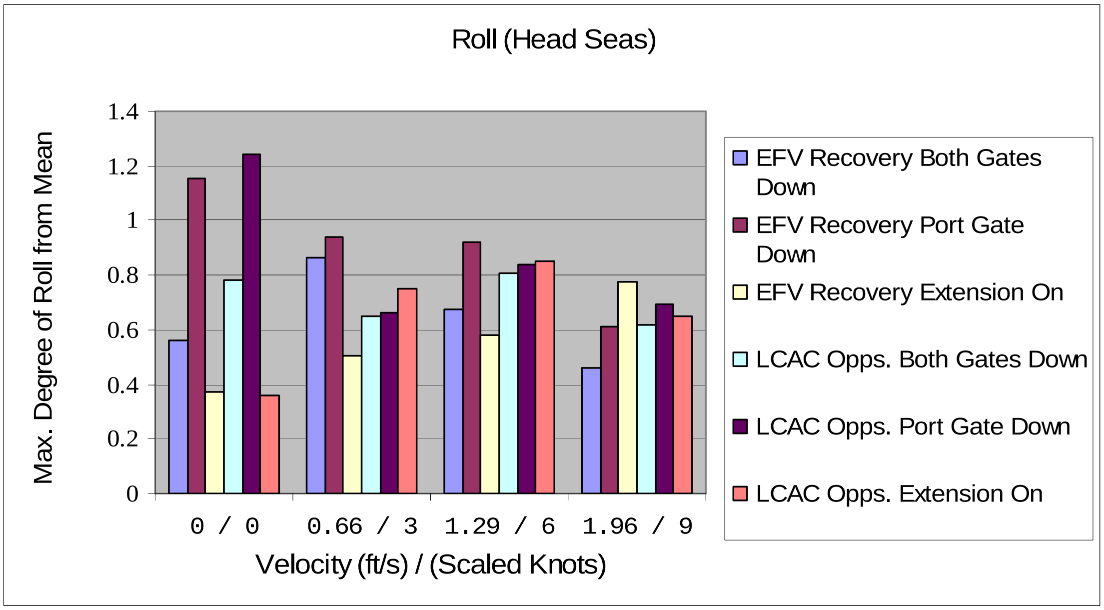

Figure 20. Comparison of *LCAC* and *EFV* Roll in *SS4* Head Seas

The water entry length plays a large role in the pitch. Though there are some slight differences between stern configurations and velocities, the range of maximum degree of pitch from the mean are consistent as shown in Figure 21. The greatest difference in the pitching range at a given velocity is 0.25 degrees at 1.29 ft/sec. At other speeds, the average difference between pitch values compared to the stern configuration is less than 0.2 degrees. The pitch is less with the extension on at every velocity due to less water entering the well decks and with the increase in ship length. The values are even more consistent regarding stern configurations at 0 ft/sec and 1.96 ft/sec, which show a difference of approximately 0.03 degrees pitch.

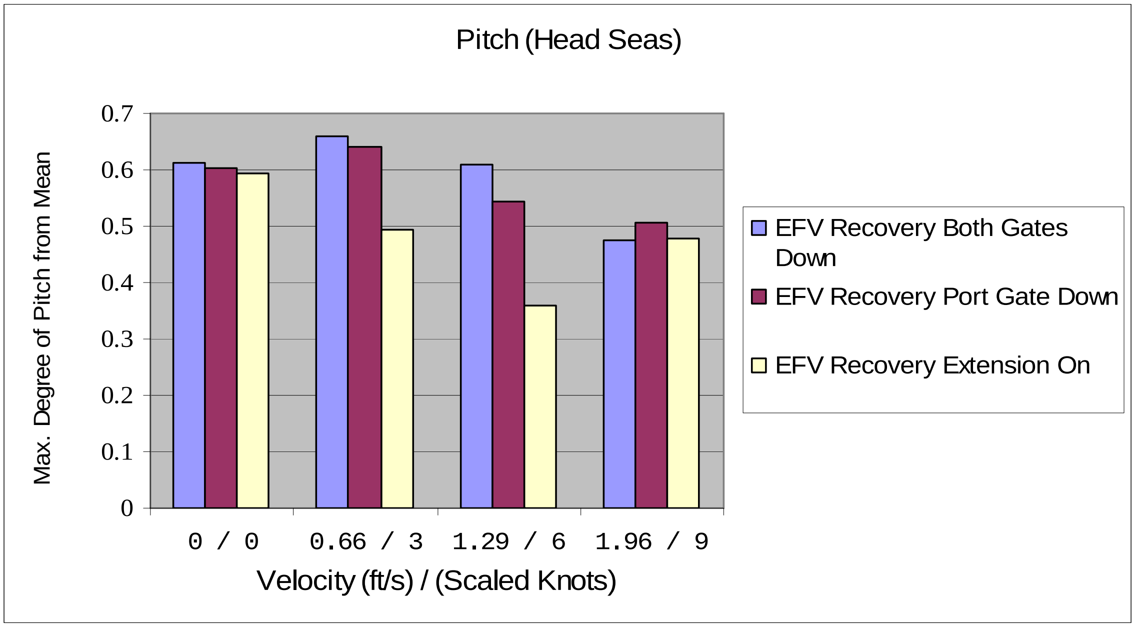

Figure 21. *EFV* Pitch in *SS4* Head Seas

The pitch results for *LCAC* operations influence water entry lengths as shown in Figure 22. The greater degree of pitch by the model leads to more water entering the deck. Pitch is fairly consistent for each stern configuration at a given velocity for *LCAC* operations, but does tend to decrease as speed increases. Individual stern configurations, as velocity increases and excluding zero velocity, are very consistent regarding the stern extension on and the port gate down cases. With both gates down, the values vary but are still within a 0.2 degree range between velocities.

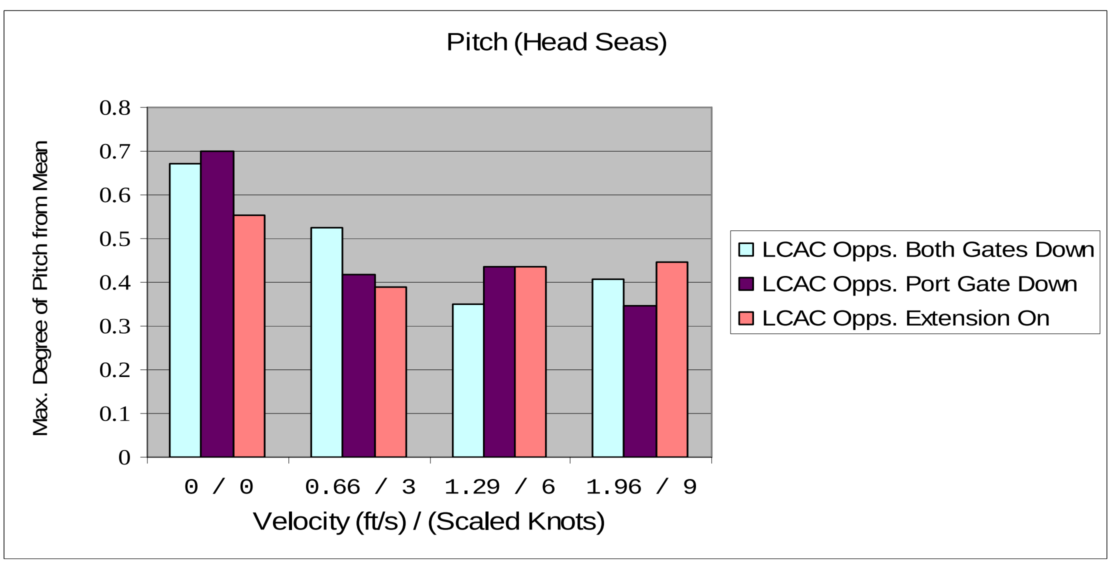

Figure 22. *LCAC* Pitch in *SS4* Head Seas

Comparing *LCAC* and *EFV* operational pitch results shows that the *LCAC* condition experiences a lesser degree of pitching. Figure 23, shows the pitch with the stern extension on yields more favorable results in both cases at lower speeds and are still true at increased speeds for the *EFV* recovery. Speed also controls the pitch experienced by the model. Increased velocity decreases the pitching motion. For seakeeping purposes, the model with the stern extension proved to be better in most cases tested.

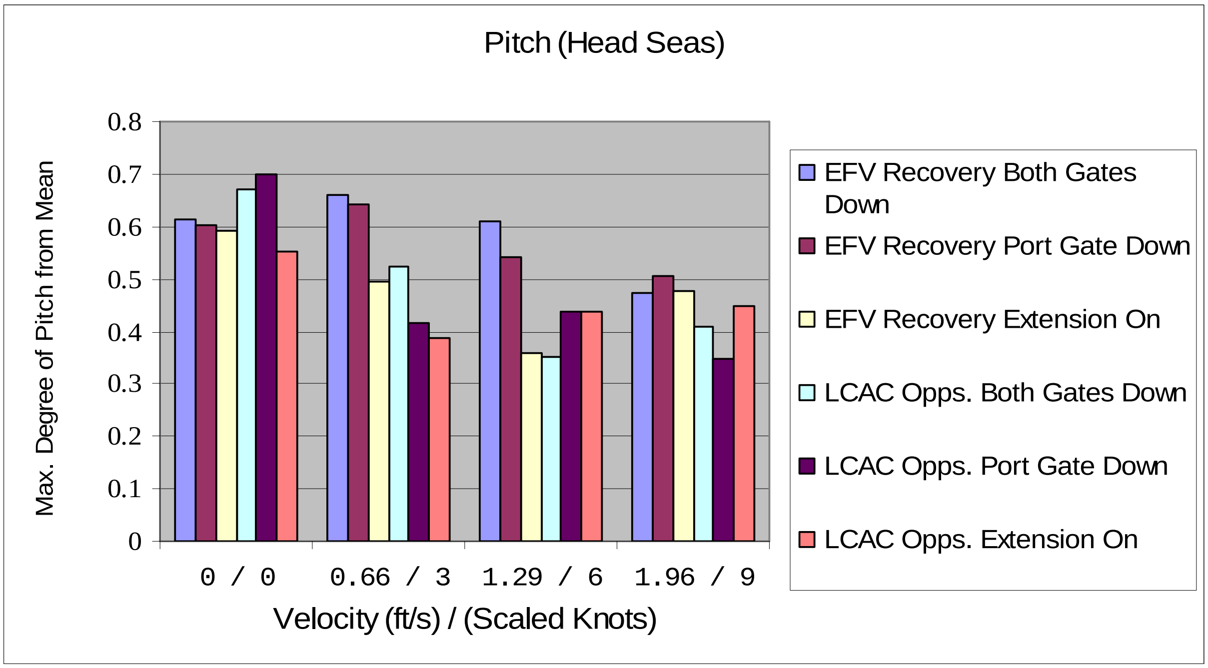

Figure 23. Comparison of *LCAC* and *EFV* Pitch in *SS4* Head Seas

6.4. Transom Wake

Flow around the transom was another focus of the *FLO/FLO* model testing. In addition, it is important to know the kind of forces influence the *EFVs* and *LCACs* as they exit and enter the vessel, so all of the gate configurations were studied.

Observations were made regarding the vortices in the wake of the ship and how they would affect the amphibious vehicles by placing the camera aft of the model during each test. Video was taken of the stern during all tests. Some photographs were also taken and stills were captured from the video to describe the interesting phenomena that occurred.

Occurrences of flow around the stern extension resulted in inconsistent wave patterns on top of the extension deck. *LCAC* conditions showed less erratic flow than *EFV* conditions due to less water rushing over the extension. However, when pitching in Sea State 4, in the *EFV* recovery condition, the extension nearly rises out of the water, and then rapidly submerged again. This rapid submergence causes water to rush over the sides and end of the extension. This causes a situation similar to flow across a sharp edged object, where the flow forms vortices. Therefore, water rushes in from both sides of the stern extension and meets on the deck causing a superposition of water. Figure 24 shows vortices wrapping around the side of the hull and the edges of the stern extension resulting in water slapping the stern extension. The worst scenario occurred when water came over both sides of the stern extension and met in the middle of the stern extension at the partition between the well decks, as shown in Figure 25. At this location, a wave would form and splash from 4 to 6 inches.

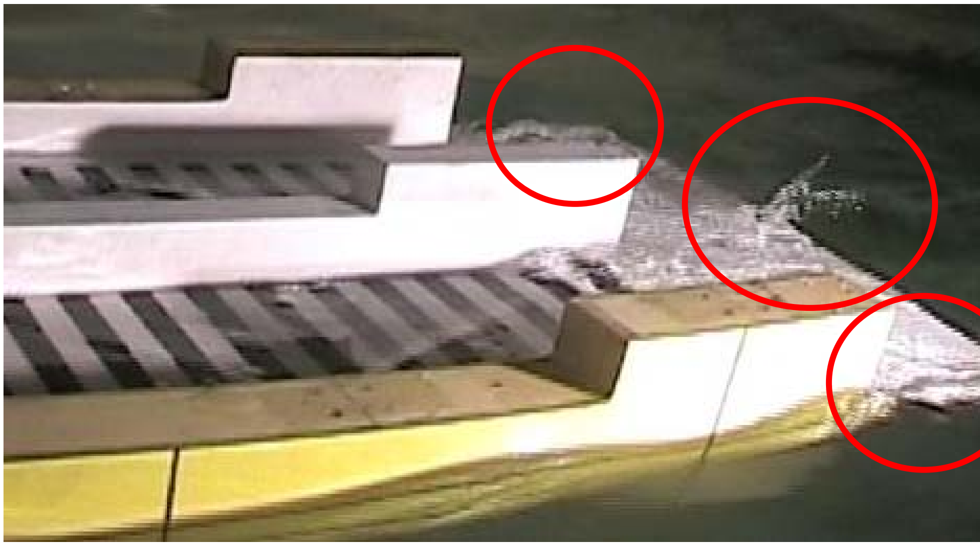

Figure 24. Side View of Water Slapping On Stern Extension, Sea State 4

Figure 25. Water Slapping On Stern Extension during Sea State 4

These results are of great concern to air cushion and amphibious vehicles loading and unloading from the *FLO/FLO*, especially *LCACs* which have very little directional control at lower speeds. *LCACs* could potentially be damaged or unable to load and unload in a safe efficient manner. *EFVs*, which do have more control than *LCACs*, will experience slamming from the ship's hull while being recovered. Also, wave slapping in the loading area may cause an *EFV* or *LCAC* to lose its course very quickly and collide with the ship.

The turbulent flow from the stern extension continues moving into and through the well decks. This causes large amounts of water to reverberate off of the well deck walls diagonally. This occurs in all conditions, but predominately with the stern extension during the *EFV* condition. In *LCAC* operations with the stern extension, the transverse motion of the water is mostly dampened a third of the way up the deck. *EFV* condition with the stern extension on, reverberating water reaches half way up the deck before it is dampened.

Without the extension present, the flow around the transom is as expected. As in most wakes, there are some vortices shed and irregularities present. However, it can be noted that a portion of the same phenomena that occurred on the stern extension occurs when the gates are down. Since the gates are not as large, the amount of water reaching over the gate does not compare with the amount reaching over the stern extension. Therefore, the phenomena seen with the stern extension is the most severe and attention needs to be given to those occurrences.

7. Conclusions

This report summarized the testing procedure and results of the *FLO/FLO* Seabasing concept model which measured water entry lengths into the well decks, seakeeping qualities, freeboard height effects in waves, and flow around the transom. The 140 foot basin was used to test the design in Sea States 2 and 4 irregular head seas for each of the four ballasting conditions. The four conditions were: *EFV* recovery with a stern extension, *EFV* recovery with gates and no extension, *LCAC* operations with a stern extension, and *LCAC* operations with gates and no extension. Gate configurations consisted of both gates down or port side gate down and were tested for both *EFV* and *LCAC* conditions. One video camera was placed at the port side of well deck to record water entry lengths as well as the water reaching over the side walls of the well deck. The other camera was placed behind the transom to record transom wake characteristics. The following conclusions were drawn:

1. Significant water entry lengths were greater with the gate configurations minus the stern extension on in all conditions

2. *LCAC* averaged 5% water entry with the stern extension on and between 70% to 90% with no stern extension in *SS*4 irregular head seas

3. *EFV* averaged 42% water entry with the stern extension on and 81% with no stern extension in *SS*4 irregular head seas

4. Water entry lengths for the *EFV* conditions were consistent at the velocities measured and were not affected by the gate configurations (zero gates, one gate up and one gate down), see Figure 16 in Section 6.1.2.

5. *LCAC* experienced high water entry lengths in the well decks due to greater pitching motions from lower drafts in *SS*4 irregular head seas

6. Roll increased with increased velocity for *EFV* with stern extension on in *SS*4 irregular head seas

7. Roll decreased with increased velocity for *EFV* with gate one gate down in *SS*4 irregular head seas

8. Most roll for *EFV* and *LCAC* occurred with port gate down, 1.17 degrees and 1.25 degrees from the mean in *SS*4 irregular head seas

9. With the stern extension on, roll increases with increasing velocity at all speeds for *EFV* and up to 1.29 ft/sec for *LCAC* in *SS*4 irregular head seas

10. The pitch motions with the stern extension on yields more favorable results in both cases at lower speeds

11. Test results show overall good seakeeping and stability at all tested conditions

12. *EFV* in *SS*4 irregular head seas without the extension encounters more water over the aft portion the side walls along the well decks than *LCAC* conditions without the extension

13. With the stern extension on no water reached over the side walls of the well decks

14. Extensive wave slapping occurs on all flat surfaces and edges of the stern extension

15. More extreme wave slapping occurs on the stern extension during *EFV* conditions in *SS*4 irregular head seas than in the *LCAC* condition in *SS*4 irregular head seas

16. Wave slapping induces erratic flow into well decks causing transverse flow to reflect off well deck walls

17. With gates and no stern extension, the water entered the well decks evenly and predictably

18. With both gates down, water slaps between the two gates similar to the wave slapping experienced with the stern extension

8. Recommendations

With the stern extension present on the model, seakeeping qualities were improved, significant water entry lengths into the deck wells were reduced, and water over the side walls was eliminated, but transom flow is a concern. The concept of the stern extension is promising, but revisions are needed to control the wave slapping and transverse flow into the well decks. Some changes could include, extending the side walls with some form of light weight barriers to dampen flow into the well decks or add appendages to divert the flow and change the direction and magnitude of vortices shed.

The reduced freeboard section of the model aft of amidships is insufficient without the stern extension. If the design does not include the extension, then the depth needs to be increased to match that of the rest of the model.

9. References

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Appendix 1: Testing

Run #	LC	Gates	SS	Vel	comments	Tape	heading	type
48	3	off	0	0	zero	1-side, 1-back	0	practice
49	3	off	0	0	zero re-zeroed drag channel	1-side, 1-back	0	practice
50	3	off	0	0	zero	1-side, 1-back	0	practice
51	3	off	2	0.66	start test 1 first practice run	1-side, 1-back	0	practice
52	3	off	2	0.66	test 1 second practice run	1-side, 1-back	0	practice
53	3	off	2	1.29	test 1 third practice run	1-side, 1-back	0	practice
54	3	off	2	1.29	test 1 fourth practice run	1-side, 1-back	0	practice
55	3	off	0	0	zero end test day	1-side, 1-back	0	zero
56	3	off	0	0	zero-removed 2gal water from model, fixed bungies to prevent yaw,resealed/taped stern dk	1-side, 1-back	0	zero
57	3	off	0	0	zero	1-side, 1-back	0	zero
58	3	off	2	0.66	test1-water on dk: lost data in excel/power out til run 68	1-side, 1-back	0	seakeeping
59	3	off	2	0.66	test2-water on dk	1-side, 1-back	0	seakeeping
60	3	off	2	1.29	test1-water on dk	1-side, 1-back	0	seakeeping
61	3	off	2	1.96		1-side, 1-back	0	seakeeping
62	3	off	2	1.96		1-side, 1-back	0	seakeeping
63	3	off	2	2.61		1-side, 1-back	0	seakeeping
64	3	off	2	2.61		1-side, 1-back	0	seakeeping
65	3	off	2	0		1-side, 1-back	0	seakeeping
66	3	off	3	0.66	wrong waves-water on dk to seam	1-side, 1-back	0	practice
67	3	off	3	0.66	wrong waves-water on dk to seam	1-side, 1-back	0	practice
68	3	off	3	0.66	wrong waves-water on dk to seam	1-side, 1-back	0	practice
69	3	off	3	0.66	wrong waves-water on dk to seam	1-side, 1-back	0	practice
70	3	off	3	0	wrong waves-water on dk to seam	1-side, 1-back	0	practice
71	3	off	4	0	right data	1-side, 1-back	0	seakeeping
72	3	off	4	0.66	Test 1- water on dk to 3-5" behind seam-removed water from model, resealed stern dk	1-side, 1-back	0	seakeeping
73	3	off	4	0.66	Test 2- water on dk 3-5" behind seam -went to lunch, strap on	1-side, 1-back	0	seakeeping
74	3	off	0	0	zero after lunch	1-side, 1-back	0	zero
75	3	off	4	1.29	Test1-water on dk to seam more on stbd	1-side, 1-back	0	seakeeping
76	3	off	4	0.66	test 3-water on dk 3"behind seam 2" behind on STBD side	1-side, 1-back	0	seakeeping
77	3	off	4	1.29	Test 2- water on dk to seam more on stbd digital reading 1.31 dial set to 1.29	2-side, 2-back	0	seakeeping
78	3	off	4	1.29	Test 3- 3"behind seam consistently more 1-2" on stbd, looks like yawing-changed tape in recorder	2-side, 2-back	0	seakeeping
79	3	off	4	1.29	Test4- same results	2-side, 2-back	0	seakeeping
80	3	off	4	1.29	Test5-same	2-side, 2-back	0	seakeeping
81	3	off	4	1.29	Test 6-same	2-side, 2-back	0	seakeeping
82	3	off	4	1.96	Test 1-water on dk 7" behind seam less than previous lower speed	2-side, 2-back	0	seakeeping
83	3	off	4	1.96	Test 2-7" mostly a few up to seam	2-side, 2-back	0	seakeeping
84	3	off	4	1.96	Test 3-same as test 2	2-side, 2-back	0	seakeeping
85	3	off	4	1.96	Test 4-same as test 2	2-side, 2-back	0	seakeeping
86	3	off	4	1.96	Test 5-same as test 2	2-side, 2-back	0	seakeeping
87	3	off	4	1.96	Test 6- same	2-side, 2-back	0	seakeeping
88	3	off	4	1.96	Test 7-same	2-side, 2-back	0	seakeeping

89	3	off	4	1.96	Test 8-same, aft draft increased possibly	2-side, 2-back	0	seakeeping
90	3	off	4	1.96	Test 9-same	2-side, 2-back	0	seakeeping
91	3	off	4	1.96	Test 10-same digital box reading 1.99 and dial is set to 1.96	2-side, 2-back	0	seakeeping
92	3	off	4	1.96	Test 11-same	2-side, 2-back	0	seakeeping
93	3	off	4	1.96	Test 12-same	2-side, 2-back	0	seakeeping
94	3	off	4	2.61	Test 1-splashing at end of exten. Water on dk to 5" behind seam	2-side, 2-back	0	seakeeping
95	3	off	4	2.61	Test 2- water 5" behind seam	2-side, 2-back	0	seakeeping
96	3	off	4	2.61	Test 3-same	2-side, 2-back	0	seakeeping
97	3	off	4	2.61	Test 4 -same	2-side, 2-back	0	seakeeping
98	3	off	4	2.61	Test 5-same	2-side, 2-back	0	seakeeping
99	3	off	4	2.61	Test 6-same	2-side, 2-back	0	seakeeping
100	3	off	4	2.61	Test 7-same digital reading 2.64 dial reading 2.61	2-side, 2-back	0	seakeeping
101	3	off	4	2.61	Test 8- same, back camera wasn't running calm water draft looks good	2-side, 2-back	0	seakeeping
102	3	off	4	2.61	Test 9-same	2-side, 2-back	0	seakeeping
103	3	off	4	2.61	Test 10-same	2-side, 2-back	0	seakeeping
104	3	off	4	2.61	Test 11-same	2-side, 2-back	0	seakeeping
105	3	off	4	2.61	Test 12-same	2-side, 2-back	0	seakeeping
106	3	off	4	2.61	Test 13-same	2-side, 2-back	0	seakeeping
107	3	off	4	2.61	Test 14-same	2-side, 2-back	0	seakeeping
108	3	off	4	2.61	Test 15-same	2-side, 2-back	0	seakeeping
109	3	off	4	2.61	Test 16-same end load condition, moved weights for LC4, strap on end day	2-side, 2-back	0	seakeeping
110	4	off	0	0	zero-straps off, no water in hull!!!!	2-side, 2-back	0	zero
111	4	off	2	0.66	Test 1- no water on dk, .5" on edge of transom	2-side, 2-back	0	seakeeping
112	4	off	2	1.29	Test 1- water half way up on exten. Loud pop at start of test weight fell in hull, replaced weights and secured them with tape	2-side, 2-back	0	seakeeping
113	4	off	2	1.96	Test 1-no water on dk, .5" up exten.	2-side, 2-back	0	seakeeping
114	4	off	2	2.61	Test 1-no water on dk, .5" up exten.	2-side, 2-back	0	seakeeping
115	4	off	0	0	zero- calibration	2-side, 2-back	0	zero
116	4	off	2	0	concluded SS2 after this zero	2-side, 2-back	0	seakeeping
117	4	off	4	0	start of SS4 testing	2-side, 2-back	0	seakeeping
118	4	off	4	0.66	Test 1-water on all of extension average, spurts up to 6" in front of exten	2-side, 2-back	0	seakeeping
119	4	off	4	0.66	Test 2-water on all of exten avg, up to 6" in front of exten	2-side, 2-back	0	seakeeping
120	4	off	4	0.66	Test 3-same	2-side, 2-back	0	seakeeping
121	4	off	4	0.66	Test 4-same	2-side, 2-back	0	seakeeping
122	4	off	4	1.29	Test 1-water on stern exten, 5" in front of exten every once in a while	2-side, 2-back	0	seakeeping
123	4	off	4	1.29	Test 2-mess up, ignore data	2-side, 2-back	0	seakeeping
124	4	off	4	1.29	Test 3-water on stern up to 7" rest same as test 1	2-side, 2-back	0	seakeeping
125	4	off	4	1.29	Test 4-same as test 1	2-side, 2-back	0	seakeeping
126	4	off	4	1.29	Test 5-same as test 1	2-side, 2-back	0	seakeeping
127	4	off	4	1.29	Test 6-same as test 3	2-side, 2-back	0	seakeeping
128	4	off	4	1.29	Test 7-same as test 1	2-side, 2-back	0	seakeeping
129	4	off	4	1.29	Test 8-same as test 1	2-side, 2-back	0	seakeeping
130	4	off	4	1.29	Test 9-same as test 1	2-side, 2-back	0	seakeeping
131	4	off	4	1.96	Test 1-water up to front edge of exten	2-side, 2-back	0	seakeeping
132	4	off	4	1.96	Test 2-same	2-side, 2-back	0	seakeeping
133	4	off	4	1.29	Test 3-mess up with vel., same with spurts of water up	2-side, 2-back	0	seakeeping

					5" in front of exten seam,			
134	4	off	4	1.96	Test 4-same as test 1	2-side, 2-back	0	seakeeping
135	4	off	4	1.96	Test 5-same as test 1	3-side,3-back	0	seakeeping
136	4	off	4	1.96	Test 6-same as test 1	3-side,3-back	0	seakeeping
137	4	off	4	1.96	Test 7-same as test 1	3-side,3-back	0	seakeeping
138	4	off	4	1.96	Test 8-same as test 1 and spurts of 3" in front of exten	3-side,3-back	0	seakeeping
139	4	off	4	1.96	Test 9-same as test 1	3-side,3-back	0	seakeeping
140	4	off	4	1.96	Test 10-same as test 1	3-side,3-back	0	seakeeping
141	4	off	4	1.96	Test 11-same as test 1	3-side,3-back	0	seakeeping
142	4	off	4	1.96	Test 12-same as test 1	3-side,3-back	0	seakeeping
143	4	off	4	2.61	Test 1-water up to front edge of exten. Little less than 9 kn	3-side,3-back	0	seakeeping
144	4	off	4	2.61	Test 2-same as test 1	3-side,3-back	0	seakeeping
145	4	off	4	2.61	Test 3-water half way up exten	3-side,3-back	0	seakeeping
146	4	off	4	2.61	Test 4-same as test 1	3-side,3-back	0	seakeeping
147	4	off	4	2.61	Test 5-same as test 1	3-side,3-back	0	seakeeping
148	4	off	4	2.61	Test 6-same as test 1	3-side,3-back	0	seakeeping
149	4	off	4	2.61	Test 7-same as test 1	3-side,3-back	0	seakeeping
150	4	off	4	2.61	Test 8-same as test 3 with spurts of water up to front edge	3-side,3-back	0	seakeeping
151	4	off	4	2.61	Test 9-same as test 3 with spurts of water up to front edge	3-side,3-back	0	seakeeping
152	4	off	4	2.61	Test 10-same as test 1	3-side,3-back	0	seakeeping
153	4	off	4	2.61	Test 11-same as test 3 with spurts of water up to front edge	3-side,3-back	0	seakeeping
154	4	off	4	2.61	Test 12-same as test 3 with spurts of water up to front edge	3-side,3-back	0	seakeeping
155	4	off	4	2.61	Test 13-same as test 3 with spurts of water up to front edge	3-side,3-back	0	seakeeping
156	4	off	4	2.61	Test 14-same as test 3 with spurts of water up to front edge	3-side,3-back	0	seakeeping
157	4	off	4	2.61	Test 15-same as test 1	3-side,3-back	0	seakeeping
158	4	off	4	2.61	Test 16-same as test 1	3-side,3-back	0	seakeeping
159	4	off	0	0	zero-took bungies off to compare pitch data to bungies on pitch was .4588deg with and .42deg without	3-side,3-back	0	zero
160	4	off	4	0	bungies off for following tests to compare	3-side,3-back	0	seakeeping
161	4	off	4	0.66	test 1 people watching without bungies-water on exten to front edge	3-side,3-back	0	seakeeping
162	4	off	4	1.29	Test 2 people watching without bungies-water up to front edge exten	3-side,3-back	0	seakeeping
163	4	off	4	1.96	Test 3 people watching without bungies-forgot to watch the water on exten!!!	3-side,3-back	0	seakeeping
164	4	off	4	2.61	Test 4 people watching without bungies-water on exten front edge	3-side,3-back	0	seakeeping
165	4	off	4	0.66	Test 2-looks like its yawing, water to edge of exten. And up to 4" at spurts	cameras off	0	seakeeping
166	4	off	4	1.29	Test 2-water up to front edge and up to 7" past edge, not yawing	cameras off	0	seakeeping
167	4	off	4	1.29	Test 3-water up to front edge and up to 7" past edge	cameras off	0	seakeeping
168	4	off	4	1.96	Test 2-water up to front edge and up to 4" past edge	cameras off	0	seakeeping
169	4	off	4	1.96	Test 3-water up to half exten and up to front edge	cameras off	0	seakeeping
170	4	off	4	1.96	Test 4-water up to front of exten	cameras off	0	seakeeping
171	4	off	4	2.61	Test 2-water half way up exten and spurts up to front edge	cameras off	0	seakeeping
172	4	off	4	2.61	Test 3-same	cameras off	0	seakeeping
173	4	off	4	2.61	Test 4-same	cameras off	0	seakeeping
174	4	off	4	2.61	Test 5-same-end testing for the day…LC4 done!!!!	cameras off	0	seakeeping

175	1	off	0	0	zero-started testing LC1	3-side,3-back	0	practice
176	1	off	2	0	zero test- moved to front of tank to avoid reflection of waves from back wall-power out	3-side,3-back	0	practice
177	1	off	0	0	power back on after lunch-mess up-resistance not zero	3-side,3-back	0	practice
178	1	off	0	0	power back on after lunch-mess up	3-side,3-back	0	practice
179	1	off	2	0	power back on after lunch-mess up	3-side,3-back	0	practice
180	1	off	2	0	power back on after lunch-mess up	3-side,3-back	0	practice
181	1	off	0	0	power back on after lunch-mess up	3-side,3-back	0	practice
182	1	off	0	0	power back on after lunch-mess up	3-side,3-back	0	practice
183	1	off	0	0	zero-stuff fixed	3-side,3-back	0	zero
184	1	off	2	0	Test 1	3-side,3-back	0	seakeeping
185	1	off	2	0.66	Test 1-water on dk 45" from aft end	3-side,3-back	0	seakeeping
186	1	off	2	1.29	Test 1-water on dk 45" from aft end up to 51"- looks like yawing until 1/2 way down tank-affecting drag	3-side,3-back	0	seakeeping
187	1	off	2	1.96	Test 1-water on dk 43" from aft end	3-side,3-back	0	seakeeping
188	1	off	2	2.61	Test 1-water on dk 40" from aft end	3-side,3-back	0	seakeeping
189	1	off	4	0	Test 1-changing sea state-water up to 60" average 52" from aft end	3-side,3-back	0	seakeeping
190	1	off	4	0.66	Test 1-water on dk 49" from aft end	3-side,3-back	0	seakeeping
191	1	off	4	0.66	Test 2-water on dk 50" from aft end	3-side,3-back	0	seakeeping
192	1	off	4	0.66	Test 3-water on dk 49" from aft end	3-side,3-back	0	seakeeping
193	1	off	4	0.66	Test 4-water up to 52" from aft end	3-side,3-back	0	seakeeping
194	1	off	4	1.29	Test 1-water up to 52" from aft end	3-side,3-back	0	seakeeping
195	1	off	4	1.29	Test 2-water up to 53" from aft end	3-side,3-back	0	seakeeping
196	1	off	4	1.29	Test 3-water up to 53" from aft end	3-side,3-back	0	seakeeping
197	1	off	4	1.29	Test 4-water up to 53" from aft end-yawing putting bungees back on-took water out of hull	3-side,3-back	0	seakeeping
198	1	off	0	0	zero-resealed dks removed straps	3-side,3-back	0	practice
199	1	off	4	0	Test 1-front of tank	3-side,3-back	0	practice
200	1	off	4	0	Test 1--wave reflection test, model at front of tank, waves sent for one basin length	4-side,4-back	0	practice
201	1	off	4	0	Test 2-wave reflection test, model at front of tank, waves sent for shorter time	4-side,4-back	0	practice
202	1	off	4	1.29	Test 5-water up to 51" from aft end	4-side,4-back	0	practice
203	1	off	4	1.29	Test 6-water up to 45" from aft end	4-side,4-back	0	practice
204	1	off	4	1.29	Test 7-water up to 45" from aft end	4-side,4-back	0	practice
205	1	off	4	1.29	Test 8-water up to 52" from aft end, took bungee off due to lower water on dk and not enough pitch more tests without on to compare data	4-side,4-back	0	practice
206	1	off	4	1.29	Test 9-water up to 51" from aft end, pitch increased, yaw in start	4-side,4-back	0	seakeeping
207	1	off	4	1.29	Test 10- water up to 52" from aft end, consistently higher water than with bungee	4-side,4-back	0	seakeeping
208	1	off	4	1.29	Test 11-water up to 51" from aft end	4-side,4-back	0	seakeeping
209	1	off	4	1.29	Test 12-water up to 52" from aft end	4-side,4-back	0	seakeeping
210	1	off	0	0	zero-water at 43" on dkdata not off enough to have bungees on so rezero for above tests and continue w/o bungees	4-side,4-back	0	zero
211	1	off	4	1.96	Test 1-water up to 52" from aft end	4-side,4-back	0	seakeeping
212	1	off	4	1.96	Test 2-same	4-side,4-back	0	seakeeping
213	1	off	4	1.96	Test 3- water up to 50" from aft end	4-side,4-back	0	seakeeping
214	1	off	4	1.96	Test 4-same, notice water coming up as high as side walls at aft end leaving no freeboard at times	4-side,4-back	0	seakeeping
215	1	off	4	1.96	Test 5- same	4-side,4-back	0	seakeeping
216	1	off	4	1.96	Test 6-same	4-side,4-back	0	seakeeping
217	1	off	4	1.96	Test 7-same	4-side,4-back	0	seakeeping

218	1	off	4	1.96	Test 8-same	4-side,4-back	0	seakeeping
219	1	off	4	1.96	Test 9-same	4-side,4-back	0	seakeeping
220	1	off	4	1.96	Test 10-same	4-side,4-back	0	seakeeping
221	1	off	4	1.96	Test 11- same	4-side,4-back	0	seakeeping
222	1	off	4	1.96	Test 12-same	4-side,4-back	0	seakeeping
223	1	off	0	0	zero-after lunch front of tank	4-side,4-back	0	zero
224	1	off	4	2.61	Test 1-water on dk 48" from aft…moved wght15 port 3/4" to correct roll	4-side,4-back	0	seakeeping
225	1	off	4	2.61	Test 2-water on dk52" from aft end	4-side,4-back	0	seakeeping
226	1	off	4	2.61	Test 3-same	4-side,4-back	0	seakeeping
227	1	off	4	2.61	Test 4-water on dk up to 50" from aft end	4-side,4-back	0	seakeeping
228	1	off	4	2.61	Test 5-same	4-side,4-back	0	seakeeping
229	1	off	4	2.61	Test 6-same	4-side,4-back	0	seakeeping
230	1	off	4	2.61	Test 7-same	4-side,4-back	0	seakeeping
231	1	off	4	2.61	Test 8-water up to 51" from aft end	4-side,4-back	0	seakeeping
232	1	off	4	2.61	Test 9-water up to 49" from aft end	4-side,4-back	0	seakeeping
233	1	off	4	2.61	Test 10-water up to 52" from aft end	4-side,4-back	0	seakeeping
234	1	off	4	2.61	Test 11-water up to 51" from aft end	4-side,4-back	0	seakeeping
235	1	off	4	2.61	Test 12-water up to 50" from aft end	no camera	0	seakeeping
236	1	off	4	2.61	Test 13-changed batteries on cameras-same	4-side,4-back	0	seakeeping
237	1	off	4	2.61	Test 14-same	4-side,4-back	0	seakeeping
238	1	off	4	2.61	Test 15-same	4-side,4-back	0	seakeeping
239	2	off	0	0	zero-start LC2	4-side,4-back	0	zero
240	2	off	2	0	Test 1	4-side,4-back	0	seakeeping
241	2	off	2	0.66	Test 1-water up to 15" from aft end	4-side,4-back	0	seakeeping
242	2	off	2	1.29	Test 1-water up to 15" from aft end	4-side,4-back	0	seakeeping
243	2	off	2	1.96	Test 1-water up to 13" from aft end	4-side,4-back	0	seakeeping
244	2	off	2	2.61	Test 1-water up to 13" from aft end	4-side,4-back	0	seakeeping
245	2	off	4	0	Test 1	4-side,4-back	0	seakeeping
246	2	off	4	0.66	Test 1-water up to 40" from aft end	4-side,4-back	0	seakeeping
247	2	off	4	0.66	Test 2-same	4-side,4-back	0	seakeeping
248	2	off	4	0.66	Test 3-water up to 37" from aft end	4-side,4-back	0	seakeeping
249	2	off	4	0.66	Test 4-water up to 40" from aft end	4-side,4-back	0	seakeeping
250	2	off	4	1.29	Test 1-water up to 50" from aft end	4-side,4-back	0	seakeeping
251	2	off	4	1.29	Test 2-water up to 40" from aft end	4-side,4-back	0	seakeeping
252	2	off	4	1.29	Test 3-same	4-side,4-back	0	seakeeping
253	2	off	4	1.29	Test 4-water up to 30" from aft end	4-side,4-back	0	seakeeping
254	2	off	4	1.29	Test 5-water up to 31" from aft end	4-side,4-back	0	seakeeping
255	2	off	4	1.29	Test 6-water up to 40" from aft end	4-side,4-back	0	seakeeping
256	2	off	4	1.29	Test 7-water up to 33" from aft end	4-side,4-back	0	seakeeping
257	2	off	4	1.29	Test 8-same	4-side,4-back	0	seakeeping
258	2	off	4	1.96	Test 1-water up to 33" from aft end	4-side,4-back	0	seakeeping
259	2	off	4	1.96	Test 2-water up to 41" from aft end	4-side,4-back	0	seakeeping
260	2	off	4	1.96	Test 3-water up to 33" from aft end	4-side,4-back	0	seakeeping
261	2	off	4	1.96	Test 4-water up to 40" from aft end	4-side,4-back	0	seakeeping
262	2	off	4	1.96	Test 5-water up to 33" from aft end-waves .38 not .41	4-side,4-back	0	seakeeping
263	2	off	4	1.96	Test 6-same	4-side,4-back	0	seakeeping
264	2	off	4	1.96	Test 7-same	no camera	0	seakeeping
265	2	off	4	1.96	Test 8-increased wave maker setting H/S=.7 making .40 water up to 40"	no camera	0	seakeeping

266	2	off	4	1.96	Test 9-same	no camera	0	seakeeping
267	2	off	4	1.96	Test 10-water up to 35" from aft end	no camera	0	seakeeping
268	2	off	4	1.96	Test 11-same	no camera	0	seakeeping
269	2	off	4	1.96	Test 12-same	no camera	0	seakeeping
270	2	off	0	0	zero-end of day	no camera	0	zero
271	2	off	0	0	zero-start of day-pitch reading zero not .5	no camera	0	zero
272	2	off	4	2.61	Test 1-water up 30", pitch reading .4 so it looks good	5-side,5-back	0	seakeeping
273	2	off	4	2.61	Test 2-same	5-side,5-back	0	seakeeping
274	2	off	4	2.61	Test 3-same, more freeboard at notch with waves than lower speed	5-side,5-back	0	seakeeping
275	2	off	4	2.61	Test 4-same	5-side,5-back	0	seakeeping
276	2	off	4	2.61	Test 5-same	5-side,5-back	0	seakeeping
277	2	off	4	2.61	Test 6-same	5-side,5-back	0	seakeeping
278	2	off	4	2.61	Test 7-same	5-side,5-back	0	seakeeping
279	2	off	4	2.61	Test 8-water up 28"	5-side,5-back	0	seakeeping
280	2	off	4	2.61	Test 9-water up 30"	5-side,5-back	0	seakeeping
281	2	off	4	2.61	Test 10-same	5-side,5-back	0	seakeeping
282	2	off	4	2.61	Test 11-same	5-side,5-back	0	seakeeping
283	2	off	4	2.61	Test 12-same	5-side,5-back	0	seakeeping
284	2	off	4	2.61	Test 13-water up29"	5-side,5-back	0	seakeeping
285	2	off	4	2.61	Test 14-water up 30"	5-side,5-back	0	seakeeping
286	2	off	4	2.61	Test 15-same	5-side,5-back	0	seakeeping
287	2	off	4	2.61	Test 16-same-put right gate on after test sealed and taped it water tight	5-side,5-back	0	seakeeping
288	2	STBD on	0	0	zero-one gate on	5-side,5-back	0	zero
289	2	STBD on	2	0	Test 1	5-side,5-back	0	seakeeping
290	2	STBD on	2	0.66	Test 1-water up 15"	5-side,5-back	0	seakeeping
291	2	STBD on	2	1.29	Test 1-same	5-side,5-back	0	seakeeping
292	2	STBD on	2	1.96	Test 1-same	5-side,5-back	0	seakeeping
293	2	STBD on	2	2.61	Test 1-water up 20"	5-side,5-back	0	seakeeping
294	2	STBD on	4	0	Test 1	5-side,5-back	0	seakeeping
295	2	STBD on	4	0.66	Test 1-water up 45", roll port water not over side, maybe change in pitch	5-side,5-back	0	seakeeping
296	2	STBD on	4	0.66	Test 2-same, roll not too severe	5-side,5-back	0	seakeeping
297	2	STBD on	4	0.66	Test 3-water up 47"	5-side,5-back	0	seakeeping
298	2	STBD on	4	0.66	Test 4-water up 35"	5-side,5-back	0	seakeeping
299	2	STBD on	4	1.29	Test 1-water up 35", roll signif. Water getting over side every once in a while	5-side,5-back	0	seakeeping
300	2	STBD on	4	1.29	Test 2-water up 40", water over side	5-side,5-back	0	seakeeping
301	2	STBD on	4	1.29	Test 3-same	5-side,5-back	0	seakeeping
302	2	STBD on	4	1.29	Test 4-water up 48"	5-side,5-back	0	seakeeping
303	2	STBD on	4	1.29	Test 5-water up 40"	5-side,5-back	0	seakeeping
304	2	STBD on	4	1.29	Test 6-same	5-side,5-back	0	seakeeping
305	2	STBD on	4	1.29	Test 7-water up 42"	5-side,5-back	0	seakeeping

306	2	STBD on	4	1.29	Test 8-same, yawing more than without gates	5-side,5-back	0	seakeeping
307	2	STBD on	4	1.96	Test 1-water up 33"	5-side,5-back	0	seakeeping
308	2	STBD on	4	1.96	Test 2-same, water over side less than lower speed	5-side,5-back	0	seakeeping
309	2	STBD on	4	1.96	Test 3-same	5-side,5-back	0	seakeeping
310	2	STBD on	4	1.96	Test 4-water up 38"	5-side,5-back	0	seakeeping
311	2	STBD on	4	1.96	Test 5-same	5-side,5-back	0	seakeeping
312	2	STBD on	4	1.96	Test 6-same	5-side,5-back	0	seakeeping
313	2	STBD on	4	1.96	Test 7-water up 43"	5-side,5-back	0	seakeeping
314	2	STBD on	4	1.96	Test 8-same	5-side,5-back	0	seakeeping
315	2	STBD on	4	1.96	Test 9-same	5-side,5-back	0	seakeeping
316	2	STBD on	4	1.96	Test 10-same	5-side,5-back	0	seakeeping
317	2	STBD on	4	1.96	Test 11-same	5-side,5-back	0	seakeeping
318	2	STBD on	4	1.96	Test 12-same	5-side,5-back	0	seakeeping
319	2	STBD on	4	2.61	Test 1-water up 33"	5-side,5-back	0	seakeeping
320	2	STBD on	4	2.61	Test 2-same, no waves over side but some up to top edge	5-side,5-back	0	seakeeping
321	2	STBD on	4	2.61	Test 3-same	5-side,5-back	0	seakeeping
322	2	STBD on	4	2.61	Test 4-same	5-side,5-back	0	seakeeping
323	2	STBD on	4	2.61	Test 5-water up 40"	5-side,5-back	0	seakeeping
324	2	STBD on	4	2.61	Test 6-same	5-side,5-back	0	seakeeping
325	2	STBD on	4	2.61	Test 7-same	5-side,5-back	0	seakeeping
326	2	STBD on	4	2.61	Test 8-water up to 33"	5-side,5-back	0	seakeeping
327	2	STBD on	4	2.61	Test 9-same	5-side,5-back	0	seakeeping
328	2	STBD on	4	2.61	Test 10-same	5-side,5-back	0	seakeeping
329	2	STBD on	4	2.61	Test 11-same	5-side,5-back	0	seakeeping
330	2	STBD on	4	2.61	Test 12-same	5-side,5-back	0	seakeeping
331	2	STBD on	4	2.61	Test 13-same	5-side,5-back	0	seakeeping
332	2	STBD on	4	2.61	Test 14-water up 40"	5-side,5-back	0	seakeeping
333	2	STBD on	4	2.61	Test 15-same	5-side,5-back	0	seakeeping
334	2	STBD on	4	2.61	Test 16-same	5-side,5-back	0	seakeeping
335	1	STBD on	0	0	zero-LC1	6-side,6-back	0	zero
336	1	STBD on	2	0	Test 1-water up 38"	6-side,6-back	0	seakeeping
337	1	STBD on	2	0.66	Test 1-water up 40"	6-side,6-back	0	seakeeping
338	1	STBD on	2	1.29	Test 1-water up 43"	6-side,6-back	0	seakeeping
339	1	STBD on	2	1.96	Test 1-water up 40"	6-side,6-back	0	seakeeping

340	1	STBD on	2	2.61	Test 1-water up 40"-computer issues	6-side,6-back	0	practice
341	1	STBD on			bad run	6-side,6-back	0	practice
342	1	STBD on			bad run	6-side,6-back	0	practice
343	1	STBD on	0	0	zero-reboot	6-side,6-back	0	zero
344	1	STBD on	4	0	Test 1-water up 51"	6-side,6-back	0	seakeeping
345	1	STBD on	4	0.66	Test 1-water up 50" water to top of side wall, lots of roll	6-side,6-back	0	seakeeping
346	1	STBD on	4	0.66	Test 2-same	6-side,6-back	0	seakeeping
347	1	STBD on	4	0.66	Test 3-same	6-side,6-back	0	seakeeping
348	1	STBD on	4	0.66	Test 4-water up to 55" water over side wall more than other runs, pitch and roll extreme	6-side,6-back	0	seakeeping
349	1	STBD on	4	1.29	Test 1-water up to 45" no water over side wall	6-side,6-back	0	seakeeping
350	1	STBD on	4	1.29	Test 2-water up to 48"	6-side,6-back	0	seakeeping
351	1	STBD on	4	1.29	Test 3-water up to 45"	6-side,6-back	0	seakeeping
352	1	STBD on	4	1.29	Test 4-same water over side once	6-side,6-back	0	seakeeping
353	1	STBD on	4	1.29	Test 5-same	6-side,6-back	0	seakeeping
354	1	STBD on	4	1.29	Test 6-water up to 48" water to top edge of side wall	6-side,6-back	0	seakeeping
355	1	STBD on	4	1.29	Test 7-water up to 50" water over side	6-side,6-back	0	seakeeping
356	1	STBD on	4	1.29	Test 8-same	6-side,6-back	0	seakeeping
357	1	STBD on	4	1.96	Test 1-water up to 45" water over sidewall	6-side,6-back	0	seakeeping
358	1	STBD on	4	1.96	Test 2-water up to 49"	6-side,6-back	0	seakeeping
359	1	STBD on	0	0	zero-end of day	6-side,6-back	0	zero
360	1	STBD on	0	0	zero-start of day zip drive not in use at the moment	6-side,6-back	0	zero
361	1	STBD on	4	1.96	Test 3-water up 48"	6-side,6-back	0	seakeeping
362	1	STBD on	4	1.96	Test 4-water up 47"	6-side,6-back	0	seakeeping
363	1	STBD on	4	1.96	Test 5-same	6-side,6-back	0	seakeeping
364	1	STBD on	4	1.96	Test 6-same water over side	6-side,6-back	0	seakeeping
365	1	STBD on	4	1.96	Test 7-same	6-side,6-back	0	seakeeping
366	1	STBD on	4	1.96	Test 8-water up 48"	6-side,6-back	0	seakeeping
367	1	STBD on	4	1.96	Test 9-same water over side couple times	6-side,6-back	0	seakeeping
368	1	STBD on	4	1.96	Test 10-same	6-side,6-back	0	seakeeping
369	1	STBD on	4	1.96	Test 11-same	6-side,6-back	0	seakeeping
370	1	STBD on	4	1.96	Test 12-water up 47"	6-side,6-back	0	seakeeping
371	1	STBD on	4	1.96	Test 13-water up 53" water over side	6-side,6-back	0	seakeeping
372	1	STBD on	4	2.61	Test 1-water up 50" not over side but up to edge	6-side,6-back	0	seakeeping
373	1	STBD on	4	2.61	Test 2-same	6-side,6-back	0	seakeeping

374	1	STBD on	4	2.61	Test 3-same	6-side,6-back	0	seakeeping
375	1	STBD on	4	2.61	Test 4-same	6-side,6-back	0	seakeeping
376	1	STBD on	4	2.61	Test 5-water up 47" water over side once	6-side,6-back	0	seakeeping
377	1	STBD on	4	2.61	Test 6-water up 46"	6-side,6-back	0	seakeeping
378	1	STBD on	4	2.61	Test 7-water up 47"	6-side,6-back	0	seakeeping
379	1	STBD on	4	2.61	Test 8-same	6-side,6-back	0	seakeeping
380	1	STBD on	4	2.61	Test 9-water up 48"	6-side,6-back	0	seakeeping
381	1	STBD on	4	2.61	Test 10-water up 50"	6-side,6-back	0	seakeeping
382	1	STBD on	4	2.61	Test 11-water up 48"	6-side,6-back	0	seakeeping
383	1	STBD on	4	2.61	Test 12-water up 46"	6-side,6-back	0	seakeeping
384	1	STBD on	4	2.61	Test 13-water up 48"	6-side,6-back	0	seakeeping
385	1	STBD on	4	2.61	Test 14-water up 50"	6-side,6-back	0	seakeeping
386	1	STBD on	4	2.61	Test 15-water up 48"	6-side,6-back	0	zero
387	1	STBD on	4	2.61	Test 16-water up 45"	6-side,6-back	0	seakeeping
388	1	STBD on	2	2.61	Test 2-water up 45"-put on down gate and sealed	6-side,6-back	0	seakeeping
389	1	port dwn	0	0	zero-check gyro pitch is 1.29	6-side,6-back	0	zero
390	1	port dwn	2	0	Test 1-water up 36"	6-side,6-back	0	seakeeping
391	1	port dwn	2	0.66	Test 1-water up 38"	6-side,6-back	0	seakeeping
392	1	port dwn	2	1.29	Test 1-water up 45"	6-side,6-back	0	seakeeping
393	1	port dwn	2	1.96	Test 1-water up 43"	6-side,6-back	0	seakeeping
394	1	port dwn	0	0	zero-check gyro 1.47	6-side,6-back	0	zero
395	1	port dwn	0	0	zero-check gyro 1.47	6-side,6-back	0	zero
396	1	port dwn	4	0	Test 1-water all the way up well	6-side,6-back	0	seakeeping
397	1	port dwn	4	0.66	Test 1-water up 51"	7-side,7-back	0	seakeeping
398	1	port dwn	4	0.66	Test 2-water up 52" waves over side couple times	7-side,7-back	0	seakeeping
399	1	port dwn	4	0.66	Test 3-same	7-side,7-back	0	seakeeping
400	1	port dwn	4	0.66	Test 4-same	7-side,7-back	0	seakeeping
401	1	port dwn	0	0	zero-check gyro pitch is around 0 not accurate	7-side,7-back	0	zero
402	1	port dwn	4	1.29	Test 1-water up 52" waves over side couple times	7-side,7-back	0	seakeeping
403	1	port dwn	4	1.29	Test 2-water up 48"	7-side,7-back	0	seakeeping
404	1	port dwn	4	1.29	Test 3-water up 50" waves over side	7-side,7-back	0	seakeeping
405	1	port dwn	4	1.29	Test 4-water up 48"	7-side,7-back	0	seakeeping
406	1	port dwn	4	1.29	Test 5-water up 50" waves up to edge	7-side,7-back	0	seakeeping
407	1	port dwn	4	1.29	Test 6-same	7-side,7-back	0	seakeeping

408	1	port dwn	4	1.29	Test 7-same	7-side,7-back	0	seakeeping
409	1	port dwn	4	1.29	Test 8-water up 51" waves over side a few times	7-side,7-back	0	seakeeping
410	1	port dwn	0	0	zero -1.18	7-side,7-back	0	zero
411	1	port dwn	4	1.96	Test 1- water up 54"	7-side,7-back	0	seakeeping
412	1	port dwn	4	1.96	Test 2- water up 51" waves up to side	7-side,7-back	0	seakeeping
413	1	port dwn	4	1.96	Test 3- water up 50"	7-side,7-back	0	seakeeping
414	1	port dwn	4	1.96	Test 4- water up 52"	7-side,7-back	0	seakeeping
415	1	port dwn	4	1.96	Test 5- water up 51" waves up to side	7-side,7-back	0	seakeeping
416	1	port dwn	4	1.96	Test 6- water up 50" waves over side	7-side,7-back	0	seakeeping
417	1	port dwn	4	1.96	Test 7- water up 51" waves over side	7-side,7-back	0	seakeeping
418	1	port dwn	4	1.96	Test 8- water up 51" waves over side	7-side,7-back	0	seakeeping
419	1	port dwn	4	1.96	Test 9- water up 53"	7-side,7-back	0	seakeeping
420	1	port dwn	4	1.96	Test 10- water up 51" waves over side	7-side,7-back	0	seakeeping
421	1	port dwn	4	1.96	Test 11- water up 52" waves over side	7-side,7-back	0	seakeeping
422	1	port dwn	4	1.96	Test 12- water up 52" waves over side	7-side,7-back	0	seakeeping
423	1	port dwn	0	0	zero - 1.38	7-side,7-back	0	zero
424	2	port dwn	0	0	zero- LC2 - 0.45	7-side,7-back	0	zero
425	2	port dwn	2	0	Test 1- water up N/A	7-side,7-back	0	seakeeping
426	2	port dwn	2	0.66	Test 1- water up 21"	7-side,7-back	0	seakeeping
427	2	port dwn	2	6	Test 1- water up 22"	7-side,7-back	0	seakeeping
428	2	port dwn	2	9	Test 1- water up 22"	7-side,7-back	0	seakeeping
429	2	port dwn	4	0	Test 1- water up 32"	7-side,7-back	0	seakeeping
430	2	port dwn	4	0.66	Test 1- water up 35"	7-side,7-back	0	seakeeping
431	2	port dwn	4	0.66	Test 2- water up 38"	7-side,7-back	0	seakeeping
432	2	port dwn	4	0.66	Test 3- water up to top	7-side,7-back	0	seakeeping
433	2	port dwn	4	0.66	Test 4- water to 51"	7-side,7-back	0	seakeeping
434	2	port dwn	0	0	zero - 0.47	7-side,7-back	0	zero
435	2	port dwn	4	1.29	Test 1- water up 50"	7-side,7-back	0	seakeeping
436	2	port dwn	4	1.29	Test 2- water up 49"	7-side,7-back	0	seakeeping
437	2	port dwn	4	1.29	Test 3- water up 50"	7-side,7-back	0	seakeeping
438	2	port dwn	4	1.29	Test 4- water up 51"	7-side,7-back	0	seakeeping
439	2	port dwn	4	1.29	Test 5- water up 50"	7-side,7-back	0	seakeeping
440	2	port dwn	4	1.29	Test 6- water up 55"	7-side,7-back	0	seakeeping
441	2	port dwn	4	1.29	Test 7- water up 52"	7-side,7-back	0	seakeeping

442	2	port dwn	4	1.29	Test 8- water up 51"	7-side,7-back	0	seakeeping
443	2	port dwn	0	0	zero- end of day 30June2006 - 0.42 pitch	7-side,7-back	0	zero
444	2	port dwn	0	0	zero - start of day 05July2006 - 0.23 pitch	7-side,7-back	0	zero
445	2	port dwn	0	0	zero	7-side,7-back	0	zero
446	2	port dwn	4	1.96	BAD water up 48" tow speed not on	7-side,7-back	0	practice
447	2	port dwn	4	1.96	BAD water up 46" tow speed not on	7-side,7-back	0	practice
448	2	port dwn	4	1.96	BAD water up 43" tow speed not on	7-side,7-back	0	practice
449	2	port dwn	4	1.96	BAD water up 44" tow speed not on	7-side,7-back	0	practice
450	2	port dwn	4	1.96	Test 1 - water up 43"	7-side,7-back	0	seakeeping
451	2	port dwn	4	1.96	Test 2 - water up 47"	7-side,7-back	0	seakeeping
452	2	port dwn	4	1.96	Test 3 - water up 46"	7-side,7-back	0	seakeeping
453	2	port dwn	4	1.96	Test 4 - water up 44"	7-side,7-back	0	seakeeping
454	2	port dwn	4	1.96	Test 5 - water up 44"	7-side,7-back	0	seakeeping
455	2	port dwn	4	1.96	Test 6 - water up 43"	7-side,7-back	0	seakeeping
456	2	port dwn	4	1.96	Test 7 - water up 49"	7-side,7-back	0	seakeeping
457	2	port dwn	4	1.96	Test 8 - water up 43"	7-side,7-back	0	seakeeping
458	2	port dwn	4	1.96	Test 9 - water up 48"	7-side,7-back	0	seakeeping
459	2	port dwn	4	1.96	Test 10 - water up 50"	7-side,7-back	0	seakeeping
460	2	port dwn	4	1.96	Test 11 - water up 44"	7-side,7-back	0	seakeeping
461	2	port dwn	4	1.96	Test 12 - water up 42"	7-side,7-back		seakeeping
462	2	both dwn	0	0	zero - new gate configuration	8-side, 8-back		zero
463	2	both dwn	4	0	zero - water up 44"	8-side, 8-back		zero
464	2	both dwn	2	0	zero - water up 20"	8-side, 8-back		zero
465	2	both dwn	2	0.66	Test 1 - water up 30"	8-side, 8-back		seakeeping
466	2	both dwn	2	1.29	Test 1 - water up 30"	8-side, 8-back		seakeeping
467	2	both dwn	2	1.96	Test 1 - water up 29"	8-side, 8-back		seakeeping
468	2	both dwn	0	0	zero	8-side, 8-back		zero
469	2	both dwn	4	0.66	Test 1 - water up 51"	8-side, 8-back		seakeeping
470	2	both dwn	4	0.66	Test 2 - water up 49"	8-side, 8-back		seakeeping
471	2	both dwn	4	0.66	Test 3 - water up 51"	8-side, 8-back		seakeeping
472	2	both dwn	4	0.66	Test 4 - water up 50"	8-side, 8-back		seakeeping
473	2	both dwn	0	0	zero	8-side, 8-back		zero
474	2	both dwn	0	0	zero	8-side, 8-back		zero
475	2	both dwn	4	1.29	Test 1 - water up 48", side camera turned on halfway through run	8-side, 8-back		seakeeping

476	2	both dwn	4	1.29	Test 2 - water up 46"	8-side, 8-back		seakeeping
477	2	both dwn	4	1.29	Test 3 - water up 52"	8-side, 8-back		seakeeping
478	2	both dwn	4	1.29	Test 4 - water up 49"	8-side, 8-back		seakeeping
479	2	both dwn	4	1.29	Test 5 - water up 47"	8-side, 8-back		seakeeping
480	2	both dwn	4	1.29	Test 6 - water up 48"	8-side, 8-back		seakeeping
481	2	both dwn	4	1.29	Test 7 - water up 46"	8-side, 8-back		seakeeping
482	2	both dwn	4	1.29	Test 8 - water up 48"	8-side, 8-back		seakeeping
483	2	both dwn	0	0	zero	8-side, 8-back		zero
484	2	both dwn	4	1.96	Test 1 - water up 46"	8-side, 8-back		seakeeping
485	2	both dwn	4	1.96	Test 2 - water up 47"	8-side, 8-back		seakeeping
486	2	both dwn	4	1.96	Test 3 - water up 50"	8-side, 8-back		seakeeping
487	2	both dwn	4	1.96	Test 4 - water up 51"	8-side, 8-back		seakeeping
488	2	both dwn	4	1.96	Test 5 - water up 46"	8-side, 8-back		seakeeping
489	2	both dwn	4	1.96	Test 6 - water up 48"	8-side, 8-back		seakeeping
490	2	both dwn	4	1.96	Test 7 - water up 45"	8-side, 8-back		seakeeping
491	2	both dwn	4	1.96	Test 8 - water up 46"	8-side, 8-back		seakeeping
492	2	both dwn	4	1.96	Test 9 - water up 42"	8-side, 8-back		seakeeping
493	2	both dwn	4	1.96	Test 10 - water up 47"	8-side, 8-back		seakeeping
494	2	both dwn	4	1.96	Test 11 - water up 45"	8-side, 8-back		seakeeping
495	2	both dwn	4	1.96	Test 12 - water up 50"	8-side, 8-back		seakeeping
496	2	both dwn	0	0	zero	8-side, 8-back		zero
497	1	both dwn	0	0	zero	8-side, 8-back		zero
498	1	both dwn	2	0	zero - Sea State 2	8-side, 8-back		zero
499	1	both dwn	4	0	zero - Sea State 4	8-side, 8-back		zero
500	1	both dwn	2	0.66	Test 1 - water up 42"	8-side, 8-back		seakeeping
501	1	both dwn	2	1.29	Test 1 - water up 46"	8-side, 8-back		seakeeping
502	1	both dwn	2	1.96	Test 1 - water up 42"	8-side, 8-back		seakeeping
503	1	both dwn	0	0	zero - end of day 05July2006	8-side, 8-back		zero
504	1	both dwn	0	0	zero - start of day 06July2006	8-side, 8-back		zero
505	1	both dwn	0	0	zero	8-side, 8-back		zero
506	1	both dwn	0	0	zero	8-side, 8-back		zero
507	1	both dwn	4	0.66	Test 1 - water up 54"	9-side, 9-back		seakeeping
508	1	both dwn	4	0.66	Test 2 - water up 50"	9-side, 9-back		seakeeping
509	1	both dwn	4	0.66	Test 3 - water up 50"	9-side, 9-back		seakeeping

510	1	both dwn	4	0.66	Test 4 - water up 50"	9-side, 9-back		seakeeping
511	1	both dwn	0	0	zero	9-side, 9-back		zero
512	1	both dwn	4	1.29	Test 1 - water up 51", waves up to side	9-side, 9-back		seakeeping
513	1	both dwn	4	1.29	Test 2 - water up 53", waves up to side	9-side, 9-back		seakeeping
514	1	both dwn	4	1.29	Test 3 - water up 54"	9-side, 9-back		seakeeping
515	1	both dwn	4	1.29	Test 4 - water up 53"	9-side, 9-back		seakeeping
516	1	both dwn	4	1.29	Test 5 - water up 52"	9-side, 9-back		seakeeping
517	1	both dwn	4	1.29	Test 6 - water up 52"	9-side, 9-back		seakeeping
518	1	both dwn	4	1.29	Test 7 - water up 51", waves up to side	9-side, 9-back		seakeeping
519	1	both dwn	4	1.29	Test 8 - water up 54", waves up to side	9-side, 9-back		seakeeping
520	1	both dwn	0	0	zero - 1.35 pitch	9-side, 9-back		zero
521	1	both dwn	4	1.96	Test 1 - water up 51"	9-side, 9-back		seakeeping
522	1	both dwn	4	1.96	Test 2 - water up 50"	9-side, 9-back		seakeeping
523	1	both dwn	4	1.96	Test 3 - water up 50"	9-side, 9-back		seakeeping
524	1	both dwn	4	1.96	Test 4 - water up 49"	9-side, 9-back		seakeeping
525	1	both dwn	4	1.96	Test 5 - water up 51"	9-side, 9-back		seakeeping
526	1	both dwn	4	1.96	Test 6 - water up 49"	9-side, 9-back		seakeeping
527	1	both dwn	4	1.96	Test 7 - water up 49"	9-side, 9-back		seakeeping
528	1	both dwn	4	1.96	Test 8 - water up 48"	9-side, 9-back		seakeeping
529	1	both dwn	4	1.96	Test 9 - water up 51"	9-side, 9-back		seakeeping
530	1	both dwn	4	1.96	Test 10 - water up 48"	9-side, 9-back		seakeeping
531	1	both dwn	4	1.96	Test 11 - water up 50"	9-side, 9-back		seakeeping
532	1	both dwn	4	1.96	Test 12 - water up 51"	9-side, 9-back		seakeeping
533	1	both dwn	0	0	zero - messed up	9-side, 9-back		practice
534	1	both dwn	0	0	zero - messed up	9-side, 9-back		practice
535	1	both dwn	0	0	zero - messed up	9-side, 9-back		practice
536	1	both dwn	0	0	zero	9-side, 9-back		zero
537	1	both dwn	2	0	SS2 Zero - water up to top	9-side, 9-back		seakeeping
538	1	both dwn	4	0	SS4 Zero - water up to top	9-side, 9-back		seakeeping
539	1	both dwn	4	1.29	Test 1 - water up 52"	9-side, 9-back		practice
540	1	both dwn	4	1.96	Test for speed	9-side, 9-back		practice
541	1	both dwn	4	1.29	Test 2 - water up 51"	9-side, 9-back		seakeeping
542	1	both dwn	4	1.29	Test 3 - water up 50"	9-side, 9-back		seakeeping
543	1	both dwn	0	0	zero - end of day 06July2006	9-side, 9-back		zero

544	1	both dwn	0	0	zero - start of day 07July2006	9-side, 9-back		zero
545	1	both dwn	4	1.29	Test 4 - water up 55"	9-side, 9-back		seakeeping
546	1	both dwn	4	1.29	Test 5 - water up 46"	9-side, 9-back		seakeeping
547	1	both dwn	4	1.29	Test 6 - water up 51"	9-side, 9-back		seakeeping
548	1	both dwn	4	1.29	Test 7 - water up 55"	9-side, 9-back		seakeeping
549	1	both dwn	4	1.29	Test 8 - water up 53"	9-side, 9-back		seakeeping
550	1	both dwn	2	1.29	Test 1 - water up 46"	9-side, 9-back		seakeeping
551	1	both dwn	0	0	zero	9-side, 9-back		zero
552	2	both dwn	0	0	zero	9-side, 9-back		zero
553	2	both dwn	2	0	Test 1 - water up 21"	9-side, 9-back		seakeeping
554	2	both dwn	2	1.29	Test 1 - water up 22"	9-side, 9-back		seakeeping
555	2	both dwn	4	0	water up 52"	9-side, 9-back		seakeeping
556	2	both dwn	4	1.29	Test 1 - water up to top	9-side, 9-back		seakeeping
557	2	both dwn	4	1.29	Test 2 - water up 50"	9-side, 9-back		seakeeping
558	2	both dwn	4	1.29	Test 3 - water up 54"	9-side, 9-back		seakeeping
559	2	both dwn	4	1.29	Test 4 - water up 53"	9-side, 9-back		seakeeping
560	2	both dwn	4	1.29	Test 5 - water up 53"	9-side, 9-back		seakeeping
561	2	both dwn	4	1.29	Test 6 - water up 52"	9-side, 9-back		seakeeping
562	2	both dwn	4	1.29	Test 7 - water up 55"	9-side, 9-back		seakeeping
563	2	both dwn	4	1.29	Test 8 - water up to top	9-side, 9-back		seakeeping
564	2	both dwn	0	0	zero	9-side, 9-back		zero
565	2	stbd dwn	0	0	zero	9-side, 9-back		zero
566	2	stbd dwn	4	0	Test 1 - water up to top	10-side, 10-back		seakeeping
567	2	stbd dwn	4	1.29	Test 1 - water up 55"	10-side, 10-back		seakeeping
568	2	stbd dwn	4	1.29	Test 2 - water up 53"	10-side, 10-back		seakeeping
569	2	stbd dwn	4	1.29	Test 3 - water up 48"	10-side, 10-back		seakeeping
570	2	stbd dwn	4	1.29	Test 4 - water up 52"	10-side, 10-back		seakeeping
571	2	stbd dwn	4	1.29	Test 5 - water up 52"	10-side, 10-back		seakeeping
572	2	stbd dwn	4	1.29	Test 6 - water up 54"	10-side, 10-back		seakeeping
573	2	stbd dwn	4	1.29	Test 7 - water up 53"	10-side, 10-back		seakeeping
574	2	stbd dwn	4	1.29	Test 8 - water up 54"	10-side, 10-back		seakeeping
575	2	stbd dwn	2	0	Test 1 - water up 26"	10-side, 10-back		seakeeping
576	2	stbd dwn	2	1.29	Test 1 - water up 18"	10-side, 10-back		seakeeping
577	2	stbd dwn	0	0	zero	10-side, 10-back		zero

578	1	stbd dwn	0	0	zero	10-side, 10-back		zero
579	1	stbd dwn	0	0	zero	10-side, 10-back		zero
580	1	stbd dwn	2	1.29	Test 1 - water up 33"	10-side, 10-back		seakeeping
581	1	stbd dwn	2	0	Test 1 - water up 36"	10-side, 10-back		seakeeping
582	1	stbd dwn	4	0	Test 1 - water up to top	10-side, 10-back		seakeeping
583	1	stbd dwn	4	1.29	Test 1 - water up 51"	10-side, 10-back		seakeeping
584	1	stbd dwn	4	1.29	Test 2 - water up 50"	10-side, 10-back		seakeeping
585	1	stbd dwn	4	1.29	Test 3 - water up 53"	10-side, 10-back		seakeeping
586	1	stbd dwn	4	1.29	Test 4 - water up 55"	10-side, 10-back		seakeeping
587	1	stbd dwn	4	1.29	Test 5 - water up 49"	10-side, 10-back		seakeeping
588	1	stbd dwn	4	1.29	Test 6 - water up 51"	10-side, 10-back		seakeeping
589	1	stbd dwn	4	1.29	Test 7 - water up 54"	10-side, 10-back		seakeeping
590	1	stbd dwn	4	1.29	Test 8 - water up 50"	10-side, 10-back		seakeeping
591	1	stbd dwn	0	0	zero	10-side, 10-back		zero

Table 8. Model Testing Run List

Appendix 2: Ship Characteristics

EFV Recovery		Gates Closed	Gates Open	GatesSplit	Extension On
Volume	**ft^3**	14.93	14.58	14.76	14.25
KB	**ft**	0.40	0.40	0.40	0.37
I_{xx}	**ft^4**	10.53	8.42	9.48	9.25
BM	**ft**	0.71	0.58	0.64	0.65
KM	**ft**	1.11	0.97	1.04	1.02
LCB +aft FP	**ft**	6.82	6.72	6.77	7.13
A_{wp}	**ft^2**	24.94	18.26	21.60	21.05
LCAC Operations		**Gates Closed**	**Gates Open**	**GatesSplit**	**Extension On**
Volume	**ft^3**	14.75	14.75	14.75	14.28
KB	**ft**	0.40	0.40	0.40	0.38
I_{xx}	**ft^4**	10.70	10.70	10.70	11.59
BM	**ft**	0.73	0.73	0.73	0.81
KM	**ft**	1.13	1.13	1.13	1.19
LCB +aft FP	**ft**	6.52	6.52	6.52	6.81
A_{wp}	**ft^2**	25.36	25.36	25.36	27.37

Table 9. ***FLO/FLO*** **Model Strip Theory Hydrostatics Based On Rhino Offsets**

lambda= 60 Model Scale - Fresh Water					
characteristic	**units**	**EFV no Extension**	**LCAC no Extension**	**EFV w/ Extension**	**LCAC w/ Extension**
LOA (ft)	ft	12.69	12.69	13.62	13.62
LWL (ft)	ft	13.19	12.46	13.19	12.30
Lpp	ft	13.07	13.07	13.07	13.07
Beam	ft	2.35	2.35	2.35	2.35
Beam at WL	ft	2.29	2.29	2.28	2.29
Draft AP	ft	0.87	0.77	0.83	0.72
Draft FP	ft	0.61	0.66	0.48	0.55
Trim Angle	deg	-1.15	-0.48	-1.51	-0.77
Trim	fr	-0.26	-0.11	-0.34	-0.17
Volume	ft3	14.60	14.38	15.57	14.89
Volume (model)	ft3	11.13	13.91	14.10	14.38
Displacement	lb	910.89	897.28	971.37	929.06
Displacement model	lb	694.62	868.20	879.57	897.31
Wetted Surface	ft2	36.74	17.59	38.23	38.58
Awp	ft2	25.10	25.75	24.70	25.75
Ixx	ft4	*13.26*	*12.53*	*13.08*	*12.23*
KG	ft	0.54	0.54	0.54	0.54
KB	ft	0.27	0.27	0.34	0.35
GM	ft	*0.64*	*0.60*	*0.64*	*0.63*
Free Surface Corr	ft	0.00	0.00	0.00	0.00
LCB aft FP	ft	6.25	6.36	7.14	0.00
LCF aft FP	ft	6.82	6.73	6.80	7.19
LCG aft FP	ft	7.11	6.69	7.11	6.69
Green # are inputs from Rhino, Red # are Equations found from values in the table					

Table 10. ***FLO/FLO*** **Model Characteristics Found From Testing**

Appendix 3: Ballasting Weights

Load Condition 3

Weight	Longitudinal *	Transverse *	Vertical *
14	58.5	3	5
8	58.5	-3	5
1	58	0	6
3	35.5	-3.5	4
15	35.5	0	2
5	17.5	3.5	6.5
2	17.5	-3.5	6.5
100	17.5	0	6
Accelerometer	8	0	4
Gimbel	3	0	6
Midship			
Gyro	-3	-4	4
24	-20	9	6
25	-20	-9	6
9	-34.5	-9	4.5
17	-34.5	9	4.5
11	-41.25	-8	5.5
4	-53	0	5.5
28	-56	5	5.5
13	-56	-5	5.5
16	-60	3.5	5.5
7	-60	-3.5	5.5
101	-65	-3.5	5.5

* Distances in inches from centerline and midline

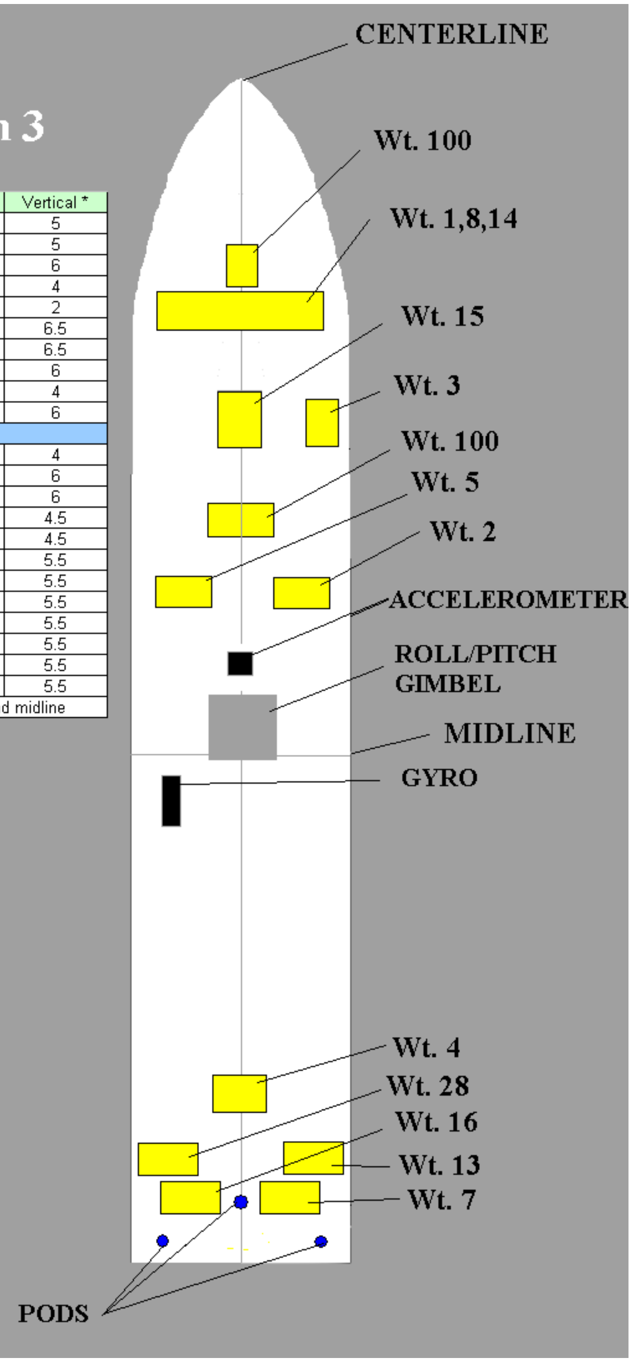


Figure 26. *EFV* Recovery with Extension On Weight Placement

Load Condition 1

Weight	Longitudinal *	Transverse *	Vertical *
100	60.5	0	11
10	59.5	0	7
14	58.5	3	5
8	58.5	-3	5
1	58	0	6
102	42.25	0	2
3	35.5	-3.5	4
5	17.5	3.5	6.5
2	17.5	-3.5	6.5
15	17.5	0	5.5
Accelerometer	8	0	4
Gimbel	3	0	6
Midship			
Gyro	-3	-4	4
24	-20	9	6
25	-20	-9	6
9	-34.5	-9	4.5
17	-34.5	9	4.5
11	-41.25	-8	5.5
4	-53	0	5.5
28	-56	5	5.5
13	-56	-5	5.5
16	-60	3.5	5.5
7	-60	-3.5	5.5
101	-65	-3.5	5.5
* Distances in inches from centerline and midline			

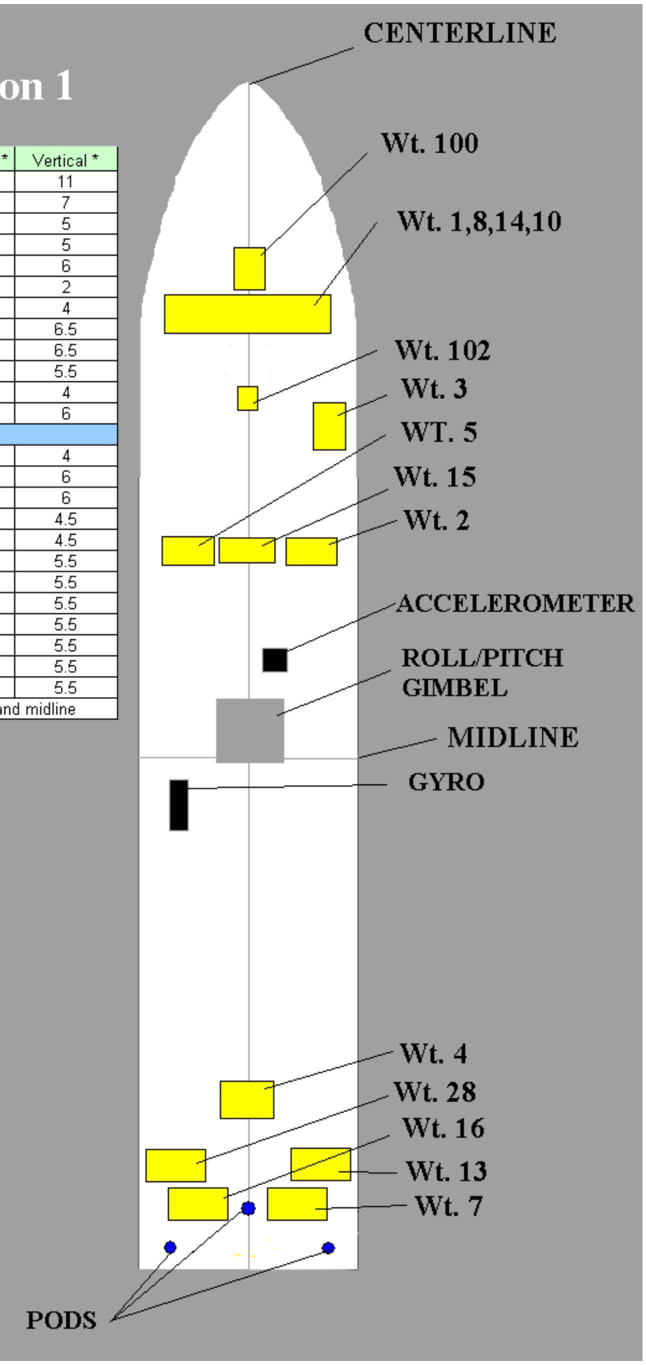
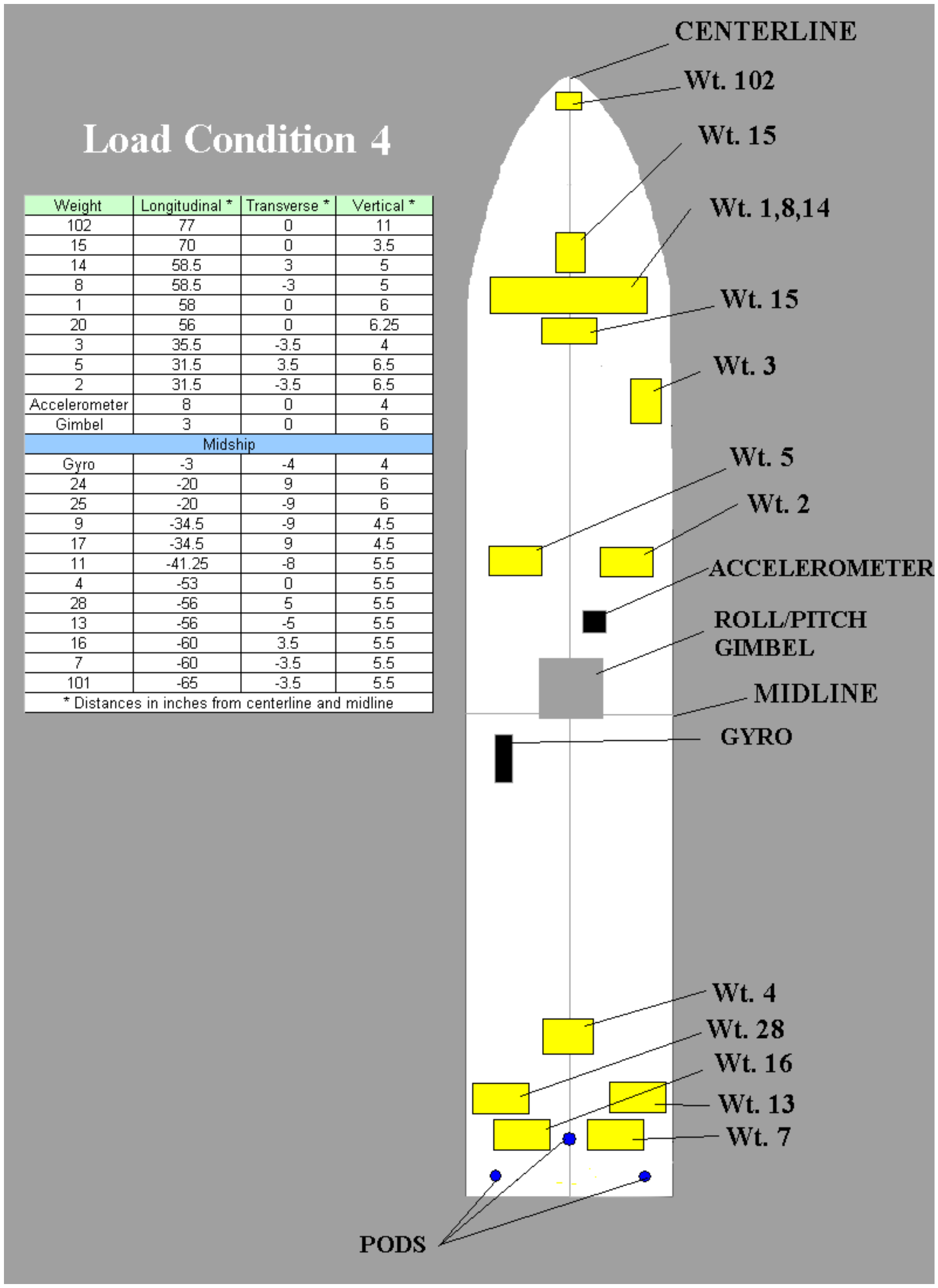


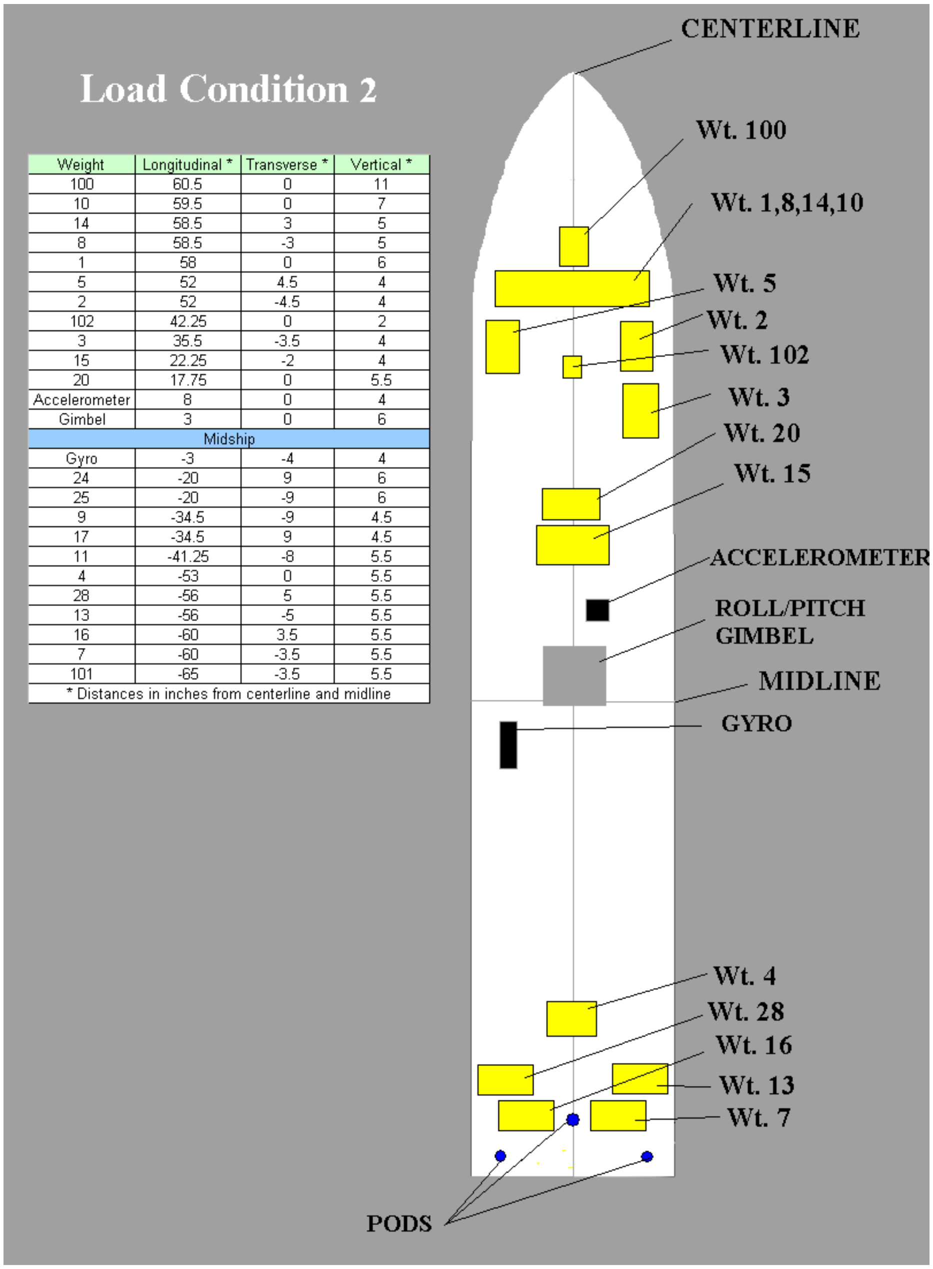
Figure 27. *EFV* Recovery without Stern Extension Weight Placement



Weight	Longitudinal *	Transverse *	Vertical *
102	77	0	11
15	70	0	3.5
14	58.5	3	5
8	58.5	-3	5
1	58	0	6
20	56	0	6.25
3	35.5	-3.5	4
5	31.5	3.5	6.5
2	31.5	-3.5	6.5
Accelerometer	8	0	4
Gimbel	3	0	6
Midship			
Gyro	-3	-4	4
24	-20	9	6
25	-20	-9	6
9	-34.5	-9	4.5
17	-34.5	9	4.5
11	-41.25	-8	5.5
4	-53	0	5.5
28	-56	5	5.5
13	-56	-5	5.5
16	-60	3.5	5.5
7	-60	-3.5	5.5
101	-65	-3.5	5.5

* Distances in inches from centerline and midline

Figure 28. ***LCAC*** **Operations with Stern Extension Weight Placement**



Weight	Longitudinal *	Transverse *	Vertical *
100	60.5	0	11
10	59.5	0	7
14	58.5	3	5
8	58.5	-3	5
1	58	0	6
5	52	4.5	4
2	52	-4.5	4
102	42.25	0	2
3	35.5	-3.5	4
15	22.25	-2	4
20	17.75	0	5.5
Accelerometer	8	0	4
Gimbel	3	0	6
Midship			
Gyro	-3	-4	4
24	-20	9	6
25	-20	-9	6
9	-34.5	-9	4.5
17	-34.5	9	4.5
11	-41.25	-8	5.5
4	-53	0	5.5
28	-56	5	5.5
13	-56	-5	5.5
16	-60	3.5	5.5
7	-60	-3.5	5.5
101	-65	-3.5	5.5

* Distances in inches from centerline and midline

Figure 29. ***LCAC*** **Operations without Stern Extension Weight Placement**

Appendix 4: Calibrations

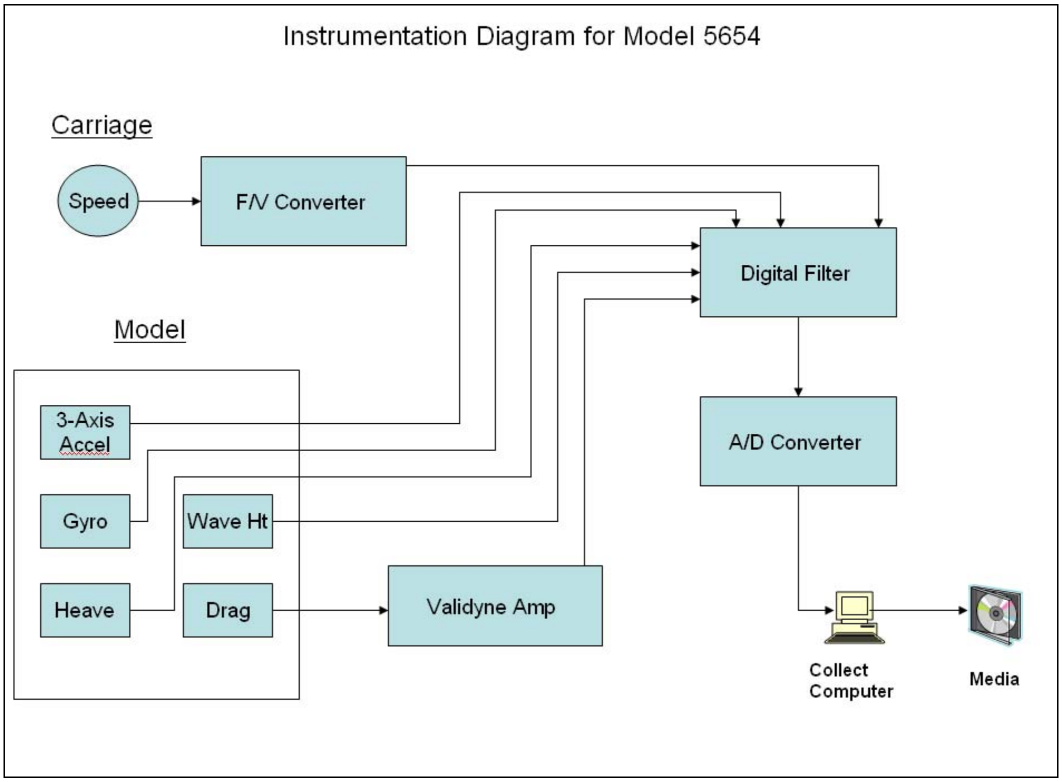


Figure 30. Instrumentation Diagram for Model

	Channel	Units	Cal Factor (units/V)	Units Offset @ 0 V	Sensor	Manufacturer	Model
1	Resistance	lbs.	10.013	-0.009	4” block gauge	N/A	50 lbs
2	CG Long Accel	g	0.127	0.001	Triaxial Accelerometer	Columbia	SA-307HPTX
3	CG Trans Accel	g	0.127	0.001	Triaxial Accelerometer	Columbia	SA-307HPTX
4	CG Vert Accel	g	0.254	0.001	Triaxial Accelerometer	Columbia	SA-307HPTX
5	Pitch	deg	3.976	-0.432	Vertical Gyro	Humphrey	VG34-0809-1
6	Roll	deg	5.909	0.084	Vertical Gyro	Humphrey	VG34-0809-1
7	Wave Height	inches	0.700	-3.464	Ultrasonic Sensor	Senix	Ultra-SR
8	Carriage speed	ft/sec	0.261	0.000	Facility	N/A	
9	Heave	inches	2.000	-19.100	Ultrasonic Sensor	Senix	Ultra-SR

Table 11. List of Model Data Channels

Appendix 5: Seakeeping

EFV Recovery Extension On					
Speed ft/sec	0.00	0.66	1.29	1.96	2.61
Heading deg	0	0	0	0	0
Sea State	4	4	4	4	4
Load Condition	EFV ext on	EFV ext on	EFV ext on	EFV ext on	EFV ext on
Gate Configuration	off	off	off	off	off
Max Roll	0.1841	0.3850	0.8754	1.2181	0.9049
Min Roll	-0.5663	-0.6254	-0.2827	-0.3359	-0.2532
Mean Roll	-0.2262	-0.2072	0.3333	0.3780	0.3216
Standard Deviation	0.1196	0.1809	0.1905	0.2993	0.2052
Normalized Max	0.4103	0.5922	0.5421	0.8401	0.5833
Normalized Min	0.3401	0.4182	0.6160	0.7138	0.5748
Avg Difference	0.5631				
LCAC Operations Extension On					
Speed ft/sec	0.00	0.66	1.29	1.96	2.61
Heading deg	0	0	0	1	0
Sea State	4	4	4	4	4
Load Condition	LCAC ext on	LCAC ext on	LCAC ext on	LCAC ext on	LCAC ext on
Gate Configuration	off	off	off	off	off
Max Roll	1.3953	0.9049	1.2772	0.8163	0.9581
Min Roll	-0.4836	-0.1941	-0.5663	-0.2827	-0.1941
Mean Roll	0.4498	0.3479	0.3658	0.2795	0.3405
Standard Deviation	0.3710	0.1997	0.2888	0.2544	0.2328
Normalized Max	0.9335	0.5419	0.9322	0.5622	0.5346
Normalized Min	0.9335	0.5419	0.9322	0.5622	0.5346
Avg Difference	0.7009				

EFV Recovery Port Gate Down				
Speed ft/sec	0.00	0.66	1.29	1.96
Heading deg	0	0	0	0
Sea State	4	4	4	4
Load Condition	EFV ext off	EFV ext off	EFV ext off	EFV ext off
Gate Configuration	port down	port down	port down	port down
Max Roll	1.1354	1.1944	1.2181	0.6745
Min Roll	-1.1749	-0.6845	-0.6254	-0.5427
Mean Roll	-0.0971	0.2218	0.1439	0.0405
Standard Deviation	0.3746	0.3729	0.3435	0.1928
Normalized Max	1.2324	0.9727	1.0741	0.6340
Normalized Min	1.0779	0.9063	0.7694	0.5832
Average Difference	0.9062			
EFV Recovery Both Gates Down				
Speed ft/sec	0.00	0.66	1.29	1.96
Heading deg	0	0	0	0
Sea State	4	4	4	4

Load Condition	EFV ext off	EFV ext off	EFV ext off	EFV ext off
Gate Configuration	both down	both down	both down	both down
Max Roll	1.0467	1.2476	1.0467	0.7277
Min Roll	-0.0759	-0.4836	-0.3063	-0.1941
Mean Roll	0.4527	0.4526	0.2935	0.2617
Standard Deviation	0.1805	0.3164	0.2984	0.1843
Normalized Max	0.5940	0.7951	0.7532	0.4660
Normalized Min	0.5287	0.9362	0.5999	0.4558
Average Difference	0.6411			
LCAC Operations Port Gate Down				
Speed ft/sec	0.00	0.66	1.29	1.96
Heading deg	0	0	0	0
Sea State	4	4	4	4
Load Condition	LCAC ext off	LCAC ext off	LCAC ext off	LCAC ext off
Gate Configuration	port down	port down	port down	port down
Max Roll	1.5371	0.8458	1.1354	0.8458
Min Roll	-0.9445	-0.4836	-0.5427	-0.5427
Mean Roll	0.3459	0.1748	0.2586	0.2756
Standard Deviation	0.4027	0.2118	0.2803	0.2859
Normalized Max	1.1912	0.6710	0.8767	0.5702
Normalized Min	1.2904	0.6584	0.8013	0.8183
Average Difference	0.8597			
LCAC Operations Both Gates Down				
Speed ft/sec	0.00	0.66	1.29	1.96
Heading deg	0	0	0	0
Sea State	4	4	4	4
Load Condition	LCAC ext off	LCAC ext off	LCAC ext off	LCAC ext off
Gate Configuration	both down	both down	both down	both down
Max Roll	1.1649	1.0763	1.2476	1.1354
Min Roll	-0.3950	-0.2236	-0.3654	-0.1055
Mean Roll	0.4799	0.4271	0.4878	0.4984
Standard Deviation	0.2383	0.2240	0.3258	0.2338
Normalized Max	0.6850	0.6492	0.7598	0.6369
Normalized Min	0.8749	0.6507	0.8533	0.6039
Average Difference	0.7142			

Table 12. Roll Results for *LCAC* and *EFV* Conditions

EFV Recovery Extension On					
Speed ft/sec	0	0.66	1.29	1.96	2.61
Heading deg	0	0	0	0	0
Sea State	4	4	4	4	4
Load Condition	EFV ext on	EFV ext on	EFV ext on	EFV ext on	EFV ext on
Gate Configuration	off	off	off	off	off
Max Pitch	2.1407	2.0611	2.0015	2.1605	2.0214
Min Pitch	0.9558	1.0711	1.2858	1.2063	1.2063

Mean Pitch	1.6259	1.5794	1.6039	1.5996	1.5945
Standard Deviation	0.2365	0.1783	0.1400	0.1714	0.1838
Normalized Max	0.5148	0.4818	0.3976	0.5609	0.4268
Normalized Min	0.6700	0.5082	0.3181	0.3933	0.3882
Avg Difference	0.4660				
LCAC Operations Extension On					
Speed ft/sec	0	0.66	1.29	1.96	2.61
Heading deg	0	0	0	0	0
Sea State	4	4	4	4	4
Load Condition	LCAC ext on	LCAC ext on	LCAC ext on	LCAC ext on	LCAC ext on
Gate Configuration	off	off	off	off	off
Max Pitch	0.9916	0.8564	0.8564	0.9161	0.7809
Min Pitch	-0.1137	0.0811	-0.0183	0.0215	0.1407
Mean Pitch	0.4405	0.4218	0.4339	0.4759	0.4535
Standard Deviation	0.2325	0.0926	0.1481	0.1766	0.1268
Normalized Max	0.5511	0.4346	0.4226	0.4401	0.3273
Normalized Min	0.5542	0.3407	0.4522	0.4545	0.3128
Average Difference	0.4290				

EFV Recovery Port Gate Down				
Speed ft/sec	0	0.66	1.29	1.96
Heading deg	0	0	0	0
Sea State	4	4	4	4
Load Condition	EFV ext off	EFV ext off	EFV ext off	EFV ext off
Gate Configuration	port down	port down	port down	port down
Max Pitch	2.0810	2.1605	2.0611	1.9856
Min Pitch	0.8763	0.8763	0.9757	0.9757
Mean Pitch	1.3906	1.3719	1.3933	1.3899
Standard Deviation	0.2234	0.2220	0.2302	0.2228
Normalized Max	0.6905	0.7887	0.6678	0.5957
Normalized Min	0.5143	0.4956	0.4176	0.4142
Average Difference	0.5730			
EFV Recovery Both Gates Down				
Speed ft/sec	0	0.66	1.29	1.96
Heading deg	0	0	0	0
Sea State	4	4	4	4
Load Condition	EFV ext off	EFV ext off	EFV ext off	EFV ext off
Gate Configuration	both down	both down	both down	both down
Max Pitch	2.1605	2.1407	2.1963	2.0810
Min Pitch	0.9359	0.8206	0.9757	1.1308
Mean Pitch	1.4402	1.3331	1.4657	1.5501
Standard Deviation	0.2141	0.2656	0.2166	0.1945
Normalized Max	0.7204	0.8076	0.7306	0.5309
Normalized Min	0.5042	0.5125	0.4900	0.4194
Average Difference	0.5894			
LCAC Operations Port Gate Down				
Speed ft/sec	0	0.66	1.29	1.96

Heading deg	0	0	0	0
Sea State	4	4	4	4
Load Condition	LCAC ext off	LCAC ext off	LCAC ext off	LCAC ext off
Gate Configuration	port down	port down	port down	port down
Max Pitch	1.0910	0.9359	0.8962	0.8365
Min Pitch	-0.3085	0.1010	0.0215	0.1407
Mean Pitch	0.4548	0.4557	0.4156	0.4345
Standard Deviation	0.2729	0.1391	0.1840	0.1271
Normalized Max	0.6362	0.4803	0.4805	0.4020
Normalized Min	0.7633	0.3547	0.3942	0.2938
Average Difference	0.4756			
LCAC Operations Both Gates Down				
Speed ft/sec	0	0.66	1.29	1.96
Heading deg	0	0	0	0
Sea State	4	4	4	4
Load Condition	LCAC ext off	LCAC ext off	LCAC ext off	LCAC ext off
Gate Configuration	both down	both down	both down	both down
Max Pitch	1.1666	1.0910	0.8962	0.9161
Min Pitch	-0.1734	0.0413	0.1964	0.1010
Mean Pitch	0.5179	0.5051	0.5438	0.4832
Standard Deviation	0.2761	0.1867	0.1392	0.1887
Normalized Max	0.6486	0.5859	0.3523	0.4329
Normalized Min	0.6913	0.4638	0.3474	0.3822
Average Difference	0.4881			

Table 13. Pitch Results for *LCAC* and *EFV* Conditions